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**USE OF NATIVE SEED MIXTURES TO IMPROVE EROSION CONTROL AND
WILDLIFE HABITAT ON LOG LANDINGS FOLLOWING TIMBER HARVEST IN
THE UPPER ELK WATERSHED OF WEST VIRGINIA**

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Thesis submitted to the College of Agriculture, Forestry, and Consumer Sciences
at West Virginia University
in partial fulfillment of the requirements for
the degree of

Master of Science
in
Wildlife and Fisheries Resources

Division of Forestry and Natural Resources

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Keywords: Compromise Programming, forage quality, forest opening, log landing, native
vegetation, sedimentation, small mammal diversity, small mammal relative abundance

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ABSTRACT

Use of Native Seed Mixtures to Improve Erosion Control and Wildlife Habitat on Log Landings Following Timber Harvest in the Upper Elk Watershed of West Virginia

Lisa R. Tager

Foresters in West Virginia follow BMP guidelines by reseeding retired log landings with inexpensive grasses that quickly provide erosion control. However, these grasses typically are not native nor do they provide high quality forage for wildlife. I developed 3 native seed mixtures for log landing reclamation that would maintain sediment control, as well as enhance wildlife habitat. These mixtures included an erosion control mixture, a wildlife mixture, and a wildflower mixture. I assessed sediment control, biomass production, vegetation structure, forage quality, and small mammal usage of my native mixtures and a commonly used, non-native traditional mixture in 2005 and 2006. No statistical analysis of sediments was conducted among mixtures due to small sample size ($n = 6$). There were no differences among mixtures in biomass production. The wildlife mixture was highest in crude protein, height and % cover among native seed mixtures. Small mammal relative abundance and species richness did not differ among mixtures. I used compromise programming analysis to find the best seed mixture for reclaiming log landings based on land management objectives. Objectives used for analysis included those of a private landowner interested in hunting, a private landowner interested in aesthetics, a timber company, and a wildlife manager. Among native mixtures, the wildlife mixture was best for all land management objectives. However, the non-native traditional mixture was the best of all 4 seed mixtures analyzed. These results suggest that although non-native traditional mixtures produce adequate physical structure to control sediment and enhance wildlife habitat, native seed mixtures are capable of serving a similar function.

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Chapter 1

Introduction and Literature Review

INTRODUCTION, RESEARCH JUSTIFICATION, AND OBJECTIVES

Forest roads, skid trails, and log landings are among the greatest contributors of non-point source pollution, particularly sedimentation, entering our streams and rivers (Egan et al. 1996, National Association of State Foresters 2001). Roads, skid trails, and landings often contain large areas of exposed soil in the Appalachians and elsewhere (Kochenderfer et al. 1997). Exposed soil is among the main contributors of stream sediments (Kochenderfer and Aubertin 1975). Once a logging site is retired, timber companies in West Virginia and other states are required to “reclaim” skid trails and log landings following Best Management Practices (BMP) that include grooming, mulching, and reseeded to reduce or prevent erosion (West Virginia Division of Forestry 2005). Prompt reseeded of skid trails and log landings following logging activity establishes vegetation and stabilizes the soil to minimize non-point source pollution. When followed properly, BMPs reduce non-point source pollution resulting from logging activities (National Association of State Foresters 2001, Vowell 2001, Edwards 2002). Best management practice timber-harvesting guidelines protect water quality by minimizing erosion and sedimentation. However, there has been an increased awareness in recent years for BMPs not only to maintain water quality, but also to protect and enhance habitat for wildlife (Ice et al. 1997, National Association of State Foresters 2001, Edwards 2002).

Timber harvest requires the construction of roads and log landings, that can negatively impact some species of wildlife. Grushecky et al. (2006) reported that nearly 9% of the Upper Elk Watershed watershed in West Virginia was converted to skid roads and log landings during harvest operations. Despite the consequences of created logging roads and landings on a variety of wildlife such as birds (Gates 1991, Chalfoun et al. 2002), herpetofauna (Gibbs 1998, Ross et al. 2000, Urbina-Cardona et al. 2006) and several species of small mammals (Lidicker 1999,

Manson et al. 1999), as well as the potential impacts of landscape-scale forest fragmentation (Murcia 1995), reclamation options can provide positive benefits for wildlife at the local scale.

Planting forest openings created by timber harvesting can improve wildlife habitat (Wentworth et al. 1990) while also maintaining erosion control. Planted landings and roads provide a source of quality forage and soft mast that may not be abundant in the surrounding forest. Early successional vegetation found in forest openings provides habitat for an abundance of invertebrates, which are an important food source for many wildlife species (Harley 1991). Forest openings planted for wildlife improve available nutrition and increase carrying capacity in the immediate area by improving the quantity and quality of food (Thill et al. 1990). Furthermore, reclaimed openings often increase diversity of cover types available to wildlife by providing edge and travel corridors among different forest habitats. Edge created by forest openings often supports small mammal communities higher in species richness and diversity than surrounding forests (Menzel et al. 1999). Forest openings also provide necessary habitat for many reptiles and amphibians (Ross et al. 2000), as well as migrant and resident avian species (Costello et al. 2000). Although the benefits of forest openings for wildlife are well documented (Thill et al. 1990, Harley 1991, Menzel et al. 1999, Costello et al. 2000, Ross et al. 2000), few studies have examined the importance of planting native vegetation in forest openings to enhance wildlife habitat.

Traditionally, loggers and foresters follow BMP guidelines by reclaiming openings with a combination of inexpensive seeds that are usually non-native, fast growing and formulated for erosion control. These seed mixtures usually contain a high percentage of grasses that control erosion, but provide little benefit to wildlife. One of the most common grasses found in traditional reclamation mixtures is fescue grass (*Festuca arundinacea*). Although known to be

highly effective for erosion control (Kochenderfer et al. 1997), fescue grass does not create high quality or diverse wildlife habitat (Menzel et al. 1999), nor is it native to the Appalachian region. Moreover, some varieties of fescue are thought to be toxic to several species of wildlife due to their association with the endophytic fungus *Acremonium coenophialum* Morgan-Jones and Gams. Wildlife, such as white-tailed deer (*Odocoileus virginianus*), that ingest endophyte-infected tall fescue may have difficulty breathing and decreased rates of weight gain and reproductive success (Schmidt et al. 1982, Bacon 1995). Infected fescue grasses also cause reduced food intake, weight gain and population size in wild rabbits (Hoveland 1993, Filipov et al. 1998), and weight loss and decreased reproduction in earthworms living in fescue dominated habitats (Humphries et al. 2001). Despite these potential risks, tall fescue is still recommended for use throughout the Appalachian region. However, the current West Virginia's BMP manual specifies the use of endophyte-free tall fescue (West Virginia Division of Forestry 2005). Non-native species can be invasive and may negatively impact native plant populations, particularly those already in decline (Litvaitis 2003). Planting non-native vegetation, although effective in reducing erosion, does not promote or delays the return to a native forest community (Holl 2002).

Concern for wildlife health and a desire for native plantings have led to a need for alternative reclamation seed mixtures. Although native herb and shrub alternatives are available and may provide both adequate erosion control and quality habitat, there has been little research to support the use of native species. The overall objective of my study was to develop and assess native seed mixtures that provide erosion control while also promoting wildlife habitat structure and forage quality. I hypothesized that although native and traditional seed mixtures may both produce adequate physical structure to control sediment, biomass and forage quality would differ

due to plant growth and nutritional characteristics. Moreover, because of differences in structure and quality, I expected to find greater abundance and diversity of small mammals in areas of greater structural diversity and forage quality. Specific objectives used to test these hypotheses included:

- (1) development of native seed mixtures for reclaiming log landings in the Upper Elk Watershed of West Virginia;
- (2) assessment of sediment control, biomass production and forage quality of traditional and native seed mixtures planted on reclaimed log landings;
- (3) assessment of wildlife species abundance and diversity among traditional and native seed mixtures planted on reclaimed log landings; and
- (4) use of compromise programming, a multi-criteria decision making technique, to assess which seed mixture was better at maintaining erosion control, while also providing wildlife habitat structure and forage quality.

LITERATURE REVIEW

Non-point Source Pollution and Best Management Practices

In the Clean Water Act of 1972 (PL 92-500) and the Water Quality Act of 1987 (PL 100-4), logging was designated as a creator of non-point source pollution (Martin and Hornbeck 1994), also referred to as stream sedimentation. Likewise, the West Virginia Water Pollution Control Act of 1974 and the 1992 Logging Sediment Control Act of West Virginia (Fig. A-1) targeted logging as the main cause of non-point source pollution in West Virginia (Wang et al. 2004). Non-point source pollution is often created by hydrologic events (Ice et al. 1997) that transport sediment from exposed soil resulting from logging. When soil is disturbed during logging and left unplanted and exposed, substantial erosion and non-point source pollution can

be emitted into streams and rivers (Hornbeck et al. 1986). It is important to point out, however, that timber removal is not the main cause of stream sedimentation, rather it is the exposed soil on logging roads, skid trails and landings used to transport logs during harvest operations (Corbet et al. 1978).

Although the Clean Water and Water Quality acts were not intended to target just forestry operations, their respective passage accelerated water quality protection within the forest industry (Ice et al. 1997). From these newly created water protection policies, state BMPs were formulated. When followed, BMPs are highly effective in minimizing non-point source pollution and erosion (Kochenderfer et al. 1997). Several states developed BMP manuals to address not only water quality problems, but also to make management suggestions for wildlife, site aesthetics, and site productivity (Aust 1994, National Association of State Foresters 2001, Edwards 2002).

Best Management Practice guidelines are particularly important in areas with steep topography and slip-prone soils, which are common in West Virginia. Best Management Practice guidelines in West Virginia include careful road and log landing planning, construction and retirement (Egan et al. 1996) (Fig. A-2). Reclamation of logging operations is to be completed within 1 week of the completion of logging (Wang et al. 2004); however, in practice this guideline is rarely met, thereby increasing the likelihood of erosion and sedimentation. If followed, BMPs prevent unnecessary damage to water resources after reclamation by establishing vegetation on erodible soils (Kochenderfer and Aubertin 1975). If re-vegetation is unsuccessful due to poor soil quality or seed success, landowners are required to reseed, fertilize, and mulch until vegetation is successful. BMPs may not prevent water-quality problems

completely, but failure to follow them can cause inadvertent impacts to stream quality (Ice et al. 1997).

West Virginia is the only state in the Southern Atlantic Region where BMPs are mandatory (Aust 1994). Since 1972, West Virginia has revised its BMP guidelines eight times. In the most recent survey of BMP compliance, Wang et al. (2004) reported log landing compliance was higher than on skid roads and log roads where compliance was less. In a stream bioassessment study to test BMP effectiveness, Vowell (2001) found that when followed properly, BMPs minimize impacts made on streams by logging. Hutchens et al. (2004) suggested that additional research was needed to assess stream biota affected by sedimentation from logging. Very few studies, aside from agricultural-based ones, have assessed the ability of vegetation to reduce sedimentation following timber harvest. Swift (1984) reported that prompt establishment of planted grasses on log road embankments minimized sediment movement to streams. In Alabama, Grace (2000) found that reclaiming log road embankments with native and exotic seed mixtures minimized soil erosion from road embankments by 66-98% immediately after establishment, and that it was reduced to nearly 100% after 30 months. Although these studies provide ample support for planting log road embankments to reduce erosion, there are no studies assessing the importance of planting log landings to reduce stream sediments, and there are very few studies assessing the ability of native vegetation to provide erosion control in logging reclamation.

Traditional Reclamation Seed Mixtures

Most loggers in West Virginia follow planting recommendations in the West Virginia BMP manual for reclamation seeding. Planting recommendations are based on cost, ease of seed acquisition, growth success, and landowner objectives. Plant species recommended for use

include tall fescue (endophyte free) (*Festuca spp.*), redtop (*Agrostis alba*), lathco flat pea (*Lathyrus sylvestris*), winter wheat (*Triticum aestivum L.*), perennial ryegrass (*Lolium perenne L.*), annual ryegrass (*Lolium multiflorum*), bird's-foot trefoil (*Lotus corniculatus L.*), orchard grass (*Dactylis glomerata L.*), ladino clover (*Trifolium repens, Ladino*), tioga deertongue (*Panicum clandestinum, Tioga*), timothy (*Phleum pratense*), and Kentucky bluegrass (*Poa pratensis*) (West Virginia Division of Forestry 2005). Although these species grow successfully in disturbed areas, only deertongue grass is native to the Appalachian region.

Reclamation Using Native Plants

Use of native plants to reclaim land disturbed by human activities has become an increasingly important topic (Richards et al. 1998, Lesica and Allendorf 1999) within the last few decades. Planting non-native vegetation in human-made forest openings may help to control erosion, but it does not take into consideration the long-term re-establishment of a healthy, native forest (Holl 2002). Many companies use seed mixtures that grow well, but contain few, if any, native species. This practice may have long-term, ecological consequences as many non-native species are also invasive and may impact native plant populations, particularly those that are already in decline (Litvaitis 2003). Daehler and Gordon (1997) even go as far as speculating that the impact of non-native species in all ecosystems around the world may be more extreme than the effects of global warming.

A native plant is one that occurs naturally in an area without deliberate human placement whereas a non-native or exotic plant is one that has not previously occurred in an area and usually results from anthropogenic actions (Manchester and Bullock 2000). Although planting exotic species, such as many grasses, has become common practice, their impacts on the environment and surrounding plant and animal communities should be considered before they

are introduced (Daehler and Gordon 1997). Exotic species often compete with native species for resources (Manchester and Bullock 2000). Such competition could result in the reduction or loss of native species from the floristic community. In a review of vegetation data from logged forests, Hansen et al. (1991) found that landings and forest roads planted with native vegetation had higher species diversity and abundance than those planted with non-native vegetation due to less invasion by exotic species. Native plant communities are important to adjoining plant communities, microorganisms, and wildlife species that depend on their presence (Hansen et al. 1991, Litvaitis 2003, Lorimer and White 2003). Any reduction in native plant species diversity could have substantial implications for long-term ecosystem health.

Log Landings as Wildlife Habitat

Log landings are small (usually < 0.4 ha) cleared areas on or adjacent to a logging site where logs are moved to, often by skidding, prior to transport offsite. Forest openings created through logging create edge that is beneficial to many wildlife species though detrimental to some. Despite the consequences of created edge habitat associated with logging roads and landings on a variety of wildlife such as birds (Gates 1991, Chalfoun et al. 2002), herpetofauna (Gibbs 1998, Ross et al. 2000, Urbina-Cardona et al. 2006) and several species of small mammals (Lidicker 1999, Manson et al. 1999), as well as the potential impacts of landscape-scale forest fragmentation (Murcia, 1995), reclamation options can provide positive benefits for wildlife at the local scale.

Planted forest openings can serve as important habitat enhancement for wildlife. Forest openings created through logging provide travel corridors among different forest habitats, as well as greater structural and plant species diversity, which is not usually present in a mature forest (Parker et al. 1992). In a study of forest edge importance to small mammal communities,

Menzel et al. (1999) found that species richness and diversity were highest in ecotones. Forest openings also provide necessary habitat for many reptiles and amphibians, particularly anurans (Ross et al. 2000), as well as migrant and resident avian species (Costello et al. 2000). Residual logs and slash provide coarse woody debris cover for many mammals, birds, invertebrates, and herpetofauna (Costello et al. 2000, Ross et al. 2000). Early successional vegetation found in many forest openings provides for an abundance of invertebrates, which are an important food source for many wildlife species (Harley 1991). Planting a log landing to create wildlife habitat is a useful way of providing food as well as enhancing habitat structure and diversity. Forest openings planted for wildlife improve available nutrition and increase carrying capacity in the immediate area by improving the quantity and quality of food (Kammermeyer and Moser 1990, Thill et al. 1990, Parker et al. 1992). Although the benefits of forest openings for wildlife are well documented (Thill et al. 1990, Wentworth et al. 1990, Harley 1991, Parker et al. 1992, Menzel et al. 1999, Costello et al. 2000, Ross et al. 2000), few studies have examined the importance of planting native vegetation in forest openings to enhance wildlife habitat.

Small mammals are an integral part of forest ecosystems, making them a good indicator of habitat conditions (Sullivan et al. 2003). Small mammal communities require low vegetation for cover, as well as abundant coarse woody debris for cover and nesting (Yahner 1992). Soft and hard mast availability is also important to small mammals. Edge created by forest openings provides a transition between early successional areas that have low vegetation with good cover and soft mast, to forested areas with coarse woody debris, hard mast, and nesting areas. For this reason, edge is beneficial for many small mammal communities (Sekgororoane and Dilworth 1995), particularly when the opening (e.g., log landing, right-of-way) provides benefits that the forest cannot.

Addition of low vegetation in forest openings creates small, temporary meadows within the forest ecosystem. Therefore, meadow-related small mammals may colonize early successional forest openings. Adams and Geis (1983) found that grassy right-of-ways yielded habitat generalists, such as deer mice (*Peromyscus spp.*), but also meadow-related species such as the meadow vole (*Microtus pennsylvanicum*). Other species that may colonize forest openings include the meadow jumping mouse (*Zapus hudsonius*), northern short-tailed shrew (*Blarina brevicauda*) (Adams and Geis 1983), and southern red-backed vole (*Clethrionomys gapperi*) (Yahner 1992) (Table A-1).

Multi-criteria Decisions/Compromise Programming

Multi criteria decision-making was first developed in the 1940's to make strategic military decisions based on conflicting objectives (de Steiguer et al. 2003). Environmental managers are increasingly using multi-criteria decisions to find management alternatives in areas where many, unrelated quantitative, qualitative, and subjective criteria and preferences are important, (Ascough et al. 2002, Schlaepfer et al. 2002) and a wider range of alternative solutions are desired (Roise et al. 2003). Watershed and forest resource managers, in particular, are using multi-criteria decision making to combine resources found in forests and watersheds and manage them as a unit (Teclé et al. 1987). By incorporating various factors in a multi-criteria decision-making analysis, managers can find the most “satisficing”, or preferred, management alternative (Teclé and Yitayew 1990) based on several different, and often conflicting, objectives. Multi-criteria decision analysis has application in forest management (Schlaepfer et al. 2002) where timber, water quality, wildlife habitat, aesthetics, recreation, soils, and other resources are important to management decisions (Teclé et al. 1987, Teclé et al. 1998, Rothley 1999), while also taking into account cost minimization and economic benefit (Williams

1997, Marshall and Homans 2004). Schlaepfer et al. (2002) used this approach to examine the feasibility of creating biological diversity for the European wolf (*Canis lupus*) in managed forests in the Swiss Alps. A habitat suitability study by Tecle et al. (1998) used multi-criteria decision-making to find the best habitat for the Albert's squirrel (*Sciurus alberti*) in Arizona. Pereira and Duckstein (1993) performed a multi-criteria decision-making analysis with a geographic information system to assess the most suitable habitat for the endangered Mount Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*), and then compared their results to actual habitat used by the squirrel. They found the analysis to have very high predictive power when assessing wildlife habitat suitability. Beromeu and Romero (2002) used a multi-criteria decision-making model to find a forest management technique that would create more diversity and greater financial return. These studies included criteria such as wildlife habitat structure, forage quality, vegetation height, vegetation biomass, runoff, sedimentation, timber growth, aesthetic value, slope, and recreation usage.

Compromise programming is a form of multi-criteria decision-making that allows managers to consider alternative management options, and weight a set of criteria to measure each option based on importance (Tkach and Simonovic 1997). The strongest criticism of compromise programming, and multi-criteria decision-making in general, is that weights assigned by the decision maker may be biased and subjective (Buchanan et al. 2004). However, as long as the decision maker remains objective, compromise programming is thought to be a very valuable tool. A decision maker chooses several alternatives to the problem they are trying to solve and places them in a compromise programming model. Several, often unrelated, criteria for each alternative are measured. Each alternative is then analyzed based on the measured criteria, and a compromise programming distance metric (CP metric) is calculated for each

alternative. The CP metric is the mathematical distance between the ideal solution that the decision maker is striving for and the alternative being analyzed. The alternative with the lowest CP metric is considered closest to the ideal solution, making it the most optimal management alternative (Zeleny 1973, Teclé et al. 1988, Pereira and Duckstein 1993, Tkach and Simonovic 1997). The decision maker can adjust the precision of decision-making by adding a p-value to the analysis. This p-value is not a statistical *P*-value. Instead, a compromise programming p-value exponentially strengthens the closest, most ideal solution in the analysis as it is increased. This allows the best decision to be made when CP metric values of alternatives are similar (Pereira and Duckstein 1993).

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Chapter 2

Use of Native Seed Mixtures to Improve Erosion Control and Wildlife Habitat on Reclaimed Log Landings Following Timber Harvest in the Upper Elk Watershed of West Virginia

USE OF NATIVE SEED MIXTURES TO IMPROVE EROSION CONTROL AND WILDLIFE HABITAT ON LOG LANDINGS FOLLOWING TIMBER HARVEST¹

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Abstract

We developed 3 native seed mixtures for log landing reclamation to control sediments and enhance wildlife habitat, including an erosion control, wildlife, and wildflower mixture. We assessed sediment control, biomass production, vegetation structure, forage quality, and small mammal response to our native mixtures and a commonly used, non-native traditional mixture during June–October in 2005 and 2006 in central West Virginia. Biomass production and small mammal relative abundance and species richness were similar among mixtures. We found the wildlife mixture had the highest crude protein content, and was highest in height and % cover among the native mixtures. Our results suggest that although non-native traditional mixtures produce adequate physical structure to control sediment and provide wildlife habitat, native seeding mixtures can provide similar benefits in reclaimed areas affected by timber harvesting.

¹ Chapter formatted in the Journal of Forest Ecology and Management style

1. Introduction

Forest roads, skid trails, and log landings contribute to non-point source pollution entering streams and rivers (Egan et al. 1996, National Association of State Foresters 2001). Roads, skid trails, and landings often contain large areas of exposed soil (Kochenderfer et al. 1997), which is among the main contributors of stream sediments (Kochenderfer and Aubertin 1975). Best Management Practices (BMPs), initiated in West Virginia in 1972, state that once a logging site is retired, timber companies are required to “reclaim” log landings and skid trails by grooming, mulching, and reseeded to reduce or prevent erosion (West Virginia Division of Forestry 2005) (Fig. A-2). Prompt reseeded following logging establishes vegetation and stabilizes the soil to minimize non-point source pollution. When properly followed, BMPs reduce non-point source pollution resulting from logging activities (National Association of State Foresters 2001, Vowell 2001, Edwards 2002). Best Management Practice timber-harvesting guidelines protect water quality by minimizing erosion and sedimentation. However, there has been an increased awareness in recent years for BMPs not only to maintain water quality, but also to protect and enhance habitat for wildlife (Ice et al. 1997, National Association of State Foresters 2001, Edwards 2002). In the Appalachian region, this has lead to an increase in planting and maintenance of forest openings created by timber harvesting to enhance wildlife habitat.

Forest openings, unlike mature or thinned forests, are generally maintained in early successional herbaceous grasses and woody shrubs. Such, early successional vegetation provides low habitat, soft mast, forage for browsing wildlife, and nesting opportunities, among other beneficial qualities. Forest openings provide edge and travel corridors, as well as greater habitat and plant species diversity that is not usually present in a mature forest (Parker et al.

1992). Edge created by forest openings often supports small mammal communities high in species richness and diversity (Menzel et al. 1999), as well as providing transition between early successional areas that have low vegetation, protective cover and soft mast, and forested areas with hard mast and nesting areas. Forest openings also provide necessary habitat for many reptiles and amphibians, particularly anurans (Ross et al. 2000), as well as both migrant and resident avian species that require early successional vegetation for nesting, cover, and food (Costello et al. 2000). Although the benefits of forest openings for wildlife have been well documented (Thill et al. 1990, Harley 1991, Menzel et al. 1999, Costello et al. 2000, Ross et al. 2000), few studies have examined the importance of planting native vegetation in forest openings to enhance wildlife habitat.

Traditionally, loggers and foresters follow BMP guidelines by reseeding retired landings and skid trails with inexpensive grasses that germinate and grow quickly to provide erosion control. However, these grasses typically are not native nor do they provide high quality forage or soft mast for wildlife. Planting non-native vegetation may control erosion, but it does not promote native vegetation or wildlife communities (Holl 2002). Although planting non-native species has become common practice, their impacts on the environment and surrounding plant and animal communities should be considered before they are introduced (Daehler and Gordon 1997). Non-native species often compete with native species for resources (Manchester and Bullock 2000). Such competition could result in the reduction or loss of native species from the floristic community. In a review of vegetation data from logged forests, Hansen et al. (1991) found that forest roads and landings planted with native vegetation had higher species diversity and abundance than forests planted with non-native vegetation due to less invasion by exotic

species. Concern for wildlife health and a desire for native plantings have created a need for native seed mixtures that maintain erosion control and improve wildlife habitat quality.

Native herb and shrub alternatives are available and may provide adequate erosion control and quality habitat, however, there has been little research to support the use of these native species. Consequently, our objective was to develop native seed mixtures to reclaim log landings that would maintain erosion control, as well as enhance wildlife habitat. We assessed sediment control, biomass production and forage quality among traditional and native seed mixtures planted on reclaimed log landings. We hypothesized that although both native and traditional seed mixtures would produce adequate physical structure to control sediment, biomass and forage quality would differ due to plant growth and nutritional characteristics. We expected these differences to manifest in greater abundance and diversity of small mammals in areas of greater structural diversity and forage quality.

2. Methods

2.1 Study Area

We conducted our study in the Upper Elk watershed located in central West Virginia. The Upper Elk watershed is found in the Allegheny Mountains physiographic region (West Virginia Division of Natural Resources 2006) and encompasses portions of southeastern Webster, southwestern Randolph, and northeastern Pocahontas counties (Fig. 2-1). Elevations within the watershed range from 700–1200 m with steep, rugged topography. Annual precipitation averages 117 cm, based on a 30-year average (Northeast Regional Climate Center 2000). Average annual temperature is 10.4°C ranging from –7.6°C in winter to 32.3°C in summer (Northeast Regional Climate Center 2000). Dominant soil types found in the Upper Elk watershed include a Snowdog silt loam and Mandy Channery silt loam (National Cooperative

Soil Survey 2006). Forested habitat within the watershed consists predominantly of Northern Hardwood/Allegheny Hardwood forest type (Stephenson 1993). Overstory composition was predominantly red maple (Acer rubrum), sugar maple (A. saccharum), American beech (Fagus grandifolia), yellow-poplar (Liriodendron tulipifera), black birch (Betula lenta), and red oak (Quercus rubra); midstory composition was red maple, sugar maple, American beech, yellow-poplar, black birch, and black locust (Robinia pseudoacacia) (Table A-2). Wild blackberry (Rubus allegheniensis) and greenbrier (Smilax spp.) dominated in the understory.

2.2. Landing Reclamation and Seed Mixture Development

We selected 20 log landings (8 in 2005; 12 in 2006) as reclamation sites. Forest stands surrounding landings were harvested 1-6 months prior to reclamation. We stratified sites into replicates (2 in 2005; 3 in 2006) that each contained 4 landings with similar pH, slope, elevation, and size. We collected soil samples from each landing to assess differences in soil nutrients among landings. Samples were collected from 3 random locations to 20 cm depth on each landing, combined, and sent to the West Virginia University Soil Analysis Lab for pH, potassium, and phosphorus content analysis to determine lime and fertilizer requirements (Table A-3). We also recorded soil pH with a handheld pH meter (Kelway HB-2, Kel Instruments Company, Inc., New Jersey) at soil sample locations to determine average pH at time of collection (Table A-3). We prepared landings for planting by scarifying the soil using a modified ripper-tooth dozer-blade assembly (Fig. 2-2). Prior to seeding, landings were smoothed with a drag harrow pulled by an ATV. Each of the 4 landings within a replicate was randomly planted with one of 4 seed mixtures: (1) traditional mixture currently used by local timber companies; (2) erosion control mixture; (3) wildlife mixture; or (4) wildflower mixture at a rate of 4.5 kg/ha (25 lb/acre) (Table 2-1). We seeded and mulched (straw 2.5-5.0 cm depth) landings

by hand in 2005 with no addition of lime or fertilizer. Following seeding and prior to mulching, we rolled landings with a lawn roller (136 kg) and ATV for improved seed to soil contact. In 2006, we used a hydroseeder for seeding and mulching (wood fiber and newspaper mulch) and did not roll landings. Lime (9.34 L/ha liquid lime) and fertilizer (5.6 kg/ha 19-19-19 water soluble pellet fertilizer) were added to the hydroseeder, based on soil test results (Table A-3) to improve seed establishment success.

Species composition among seed mixtures varied as follows: (1) erosion control mixture consisted of annual winter wheat (Triticum aestivum L.), creeping red fescue (Festuca rubra), silky wild rye (Elymus villosus), and deer-tongue grass (Panicum clandestinum, Tioga); (2) wildlife mixture consisted of ladino clover (Trifolium repens, Ladino), partridge pea (Chamaecrista fasciculata), creeping red fescue, annual winter wheat, deer tongue grass, and wild blackberry; (3) wildflower mixture consisted of black-eyed susan (Rudbeckia hirta), annual winter wheat, creeping red fescue, silky wild rye, showy tick trefoil (Desmodium canadense), wild blue lupine (Lupinus perennis), ox eye sunflower (Heliopsis helianthoides), and New England aster (Aster novae-angliae); and (4) traditional mixture contained orchard grass (Dactylis glomerata L.), perennial ryegrass (Lolium perenne L.), rye grain (Secale cereale), timothy grass (Phleum pratense), red clover (Trifolium pratense), birdsfoot trefoil (Lotus corniculatus L.), and trace amounts of various unknown seeds (Table 2-1). All seed mixtures, except for the traditional mixture, contained only native and naturalized (Ladino clover) species of plants.

2.3. Sediment Collection

To measure sediment movement from log landings, we used a modified silt fence method of collection following Robichaud and Brown (2002). This method is simple, efficient once

fences are installed, and inexpensive relative to other sediment collection techniques (Robichaud and Brown 2002). We installed sediment “wells” constructed of silt fencing (Amoco geo-textile #2016, Austell, Georgia) on the greatest slope of each log landing. We measured slope on landings using a handheld clinometer. We installed fencing in a square shape to prevent outside sediment from running into the collection area of the well (Fig. 2-3). Fencing was reduced to 0.3 m in height to reduce shading of planted vegetation inside the well area. Size of sediment wells varied from a minimum of 1 m² to a maximum of 2.5 m² depending on the area of available slope on landings. Once secured with wooden stakes, we folded excess fencing at the bottom of the slope towards the upslope (Fig. 2-3). We secured the edge of the fencing by placing turf staples every 6 cm. The upturned area of fence created a collection well from which to collect sediment.

We collected monthly sediment samples in June–October 2005 from 6 of 8 landings; wells were not established on the remaining two landings because of 0% slope. We collected sediment using shovels, brooms, and hand brushes. We removed a sub-sample (~ 300 g) from the homogenized sediment and dried it at 105 °C to a constant weight (Robichaud and Brown 2002). We calculated dry weight of sediment samples based on sub-sample weights. Planned collections in 2006 were not completed because of repeated vandalism of collection wells.

2.4. Vegetation Sampling

To assess forage quality and biomass, we randomly placed 3 circular exclosures on each landing (Fig. 2-4); we used 3 exclosures to account for variation within landings. Exclosures were 1 m in diameter and 1.5 m in height to exclude deer (Castleberry et al. 2000) and constructed of 5×10-cm welded-wire fencing and a metal post (Wentworth et al. 1990). We sampled vegetation during July and September of 2005 and 2006. Each exclosure was divided

into 4 equal sections; one section was randomly chosen and all vegetation was clipped to ground level (Fig. 2-4) and stored in a plastic bag (Plumb and Dodd 1993). Similarly, a paired, unfenced plot was simultaneously clipped to examine potential browse effects on biomass production (Wentworth et al. 1990). To reduce the conversion of sugars to starches, which could affect forage quality results, we placed samples in a cooler while they were transported to the laboratory (Haufler and Servello 1996). In the lab, we separated vegetation by species to remove vegetation that was not in the initial seed mixtures. We oven dried vegetation samples at 60 °C to a constant mass (McInnes et al. 1992). We measured browse intensity by comparing biomass of vegetation inside unbrowsed exclosures to the biomass of vegetation in paired, unfenced plots. We determined forage quality based on nutrient composition and digestibility (Haufler and Servello 1996). Dried vegetation samples were tested for crude protein content, acid detergent fiber (ADF), and neutral detergent fiber (NDF) at the West Virginia University Rumen Analysis Laboratory. Neutral detergent fiber and ADF serve as measures of palatability and digestibility, respectively, and are expressed as a percentage. Crude protein provides a measure of protein available from a composite of species found in individual seed mixtures.

Prior to clipping, we measured vegetation height and percent cover both inside and outside of exclosures to assess the structural progress of each seeding mixture. In addition to sampling vegetation on landings, in July 2006 we also clipped understory vegetation in surrounding forest plots to serve as a reference measure of forage quality and biomass found in residual stands. Forest plots were 0.25 m² and located 75 m from the landing in each of the 4 cardinal directions (North, South, East, and West). We measured vegetation height and percent cover at each plot and combined clipped vegetation for analysis as described above for landings.

2.5. *Small Mammal Sampling*

We conducted small mammal trapping using a 3-transect array (Fig. 2-5). We located 2 transects on each landing; one running through the center and a second parallel to the first along the edge of the landing to account for any edge effect (Parker et al. 1992). We placed a third transect approximately 75 m in the adjacent forest to serve as a reference for comparisons of species abundance and richness (Menzel et al. 1999). Determining animal abundances in nearby forest habitat is important in determining the true response of animals to adjacent open habitats (Francel et al. 2004).

Landing and edge transects had trapping stations at approximately 7-m intervals with numbers of trapping stations dependent on dimensions of the landing. Length of forest transects corresponded to landing transects. In 2005, we placed a ventilated Sherman live trap (Trap-LFAHD-P, H. B. Sherman Traps, Tallahassee, Florida) and a medium-sized Tomahawk live trap (#202, Tomahawk, Tomahawk Live Trap Company, Wisconsin) at each trap station to allow for capture of a greater diversity of small mammals. Because of theft and previously low capture rates of Tomahawks, we only used Sherman live traps in 2006.

We conducted 3, 4-night trapping sessions on each landing (Yates et al. 1997) during June, August, and October 2005 and 2006. Only one replicate was trapped during October 2006 due to trap theft. Because of spatial and temporal constraints, we trapped 4 landings (1 replicate) during one session and the remaining landings/replicates during other sessions. We set traps in the evening, baited them with peanut butter and oats, and checked them the following morning (Pearson and Ruggiero 2003). We identified captured animals to species (Brunjes et al. 2003), sexed, aged, and weighed them, and then marked them on their stomachs using a non-toxic permanent marker before release (Nietfeld et al. 1996, Francel et al. 2004). To account for

variability in trap numbers across sites (Francel et al. 2004), we calculated relative abundance using number of individuals captured per 100 trap nights (Chamberlain and Leopold 2003) corrected for sprung traps (Beauvais and Buskirk 1999). We calculated species richness as the number of different species recorded at each landing.

2.6. Statistical Analysis

Because we only collected sediment samples from 6 landings in 2005 and vandalism resulted in no samples in 2006, we present only summary statistics of sediment loads among seed mixtures. We used a Pearson correlation to find correlations between sediment collected and percent slope of landing. We used an incomplete blocked nested analysis of variance (ANOVA) (Proc GLM; SAS Institute Inc. 2006) to examine differences in vegetation biomass, percent cover, height, forage quality, year, and collection months among seed mixtures (Table A-4). We looked for differences between years due to differing site preparation methods used in 2005 and 2006. In our ANOVA seed mixtures served as plots, replicates were entered as a blocking factor, and collection months within each year were entered as repeated measures; exclosed, clipped plots were entered as subplots in the analysis. All percent data (% cover, %ADF, %NDF, %CP) were arcsine square root transformed to normalize distributions. We used a least squared means (LSMeans, SAS) comparison and Tukey-Kramer adjustment at $\alpha = 0.05$ experiment-wise error for multiple comparisons to look for specific differences when ANOVA found significant differences among mixtures. We used paired *t*-tests to compare biomass, percent cover, height, and forage quality between vegetation clipped in forest and landing plots in July 2006.

We used an incomplete blocked nested ANOVA to examine differences in small mammal abundance and species richness among mixtures (Table A-5). Because we were interested in

animal use only on landings, we used only center and edge transect data in our ANOVA. Similar to vegetation analysis, seed mixtures served as plots, replicates were entered as a blocking factor, and collection months within each year were entered as repeated measures. We entered transects as subplots in the analysis. We used a least squared means comparison and Tukey-Kramer adjustment for multiple comparisons to look for specific differences when ANOVA found significant differences among mixtures. We compared transects using a separate ANOVA that included center, edge, and forest transects as subplots, and used a least squared means comparison and Tukey-Kramer adjustment to examine differences in relative abundance and species richness among center, edge, and forest transects.

3. Results

3.1. Sediment

Sediment collected from landings during May–October 2005 ranged from 0.0–5.40 kg/m² (Table A-6). Although not statistically tested, the largest amount of sediment was recorded on landings planted in the wildlife seed mixture (Site 2) and the least from the landing planted in the traditional mixture (Site 1). Percent slope of landings ranged from 0.25% to 8.20%; no correlation was found between amount of sediment collected and percent slope of landing (Pearson coefficient = -0.72, $P = 0.6039$).

3.2. Vegetation

There were no differences in biomass production between years ($F_{1,13} = 1.01$, $P = 0.420$) or collection months ($F_{2,3} = 1.36$, $P = 0.263$). Biomass production varied among mixtures with the traditional mixture yielding higher amounts and the wildflower mixture the least (Table 2.2); however, there were no significant differences in biomass production ($F_{3,12} = 5.53$, $P = 0.066$).

among mixtures. Similarly, biomass production between exclosures and paired plots did not differ ($F_{4,13} = 0.61$, $P = 0.659$).

Percent NDF, ADF and crude protein were similar between years ($F_{1,9} = 1.78$, $P = 0.314$; $F_{1,9} = 16.59$, $P = 0.061$; $F_{1,9} = 19.34$, $P = 0.060$) and among collection months ($F_{2,9} = 2.12$, $P = 0.140$; $F_{2,9} = 0.35$, $P = 0.710$; $F_{2,9} = 0.36$, $P = 0.700$). Percent NDF ($F_{3,9} = 1.95$, $P = 0.144$) and percent ADF ($F_{3,9} = 0.65$, $P = 0.590$) were similar among seed mixtures (Table 2-3). Percent crude protein differed among seed mixtures ($F_{3,9} = 8.62$, $P = 0.0003$), being lower in the erosion and wildflower mixtures than in the traditional and wildlife mixtures (Table 2-3). Collected samples contained $< 10\%$ non-planted species (Table A-7), which would minimally affect forage quality of our native mixtures.

Vegetation height and percent cover on log landings was similar between years ($F_{1,17} = 1.57$, $P = 0.337$; $F_{1,17} = 2.91$, $P = 0.230$) and among collection months ($F_{2,17} = 2.13$, $P = 0.066$; $F_{2,17} = 1.51$, $P = 0.226$). Vegetation height was different among seed mixtures ($F_{3,17} = 46.03$, $P < 0.0001$) with the wildflower mixture shorter than the erosion and traditional mixtures (Table 2-4). Vegetation height on landings planted in traditional, erosion control, and wildlife seed mixtures was similar (Table 2-4). Percent cover on log landings differed among seed mixtures ($F_{3,17} = 44.99$, $P < 0.0001$). Percent cover on landings planted in traditional mixture was higher than other mixtures. The erosion and wildflower mixtures were lower in % cover than the other mixtures, but were similar to each other (Table 2-4).

Understory vegetative structure and quality were similar between log landings and surrounding forest plots except in % NDF (Table 2-5). Percent NDF was higher on landings than in the surrounding forest (Table 2-5).

3.3. *Small Mammals*

We captured 248 small mammals during 1,757 trap nights in 2005 and 239 small mammals during 1,863 trap nights in 2006 including the northern short-tailed shrew (Blarina brevicauda) ($n = 25$), southern red-backed vole (Clethrionomys gapperi) ($n = 36$), woodland vole (Microtus pinetorum) ($n = 10$), meadow vole (Microtus pennsylvanicum), woodland jumping mouse (Napaeozapus insignis) ($n = 10$), white-footed deer mouse (Peromyscus leucopus) ($n = 241$), deer mouse (Peromyscus maniculatus) ($n = 95$), masked shrew (Sorex cinereus) ($n = 2$), smoky shrew (Sorex fumeus) ($n = 26$), eastern chipmunk (Tamias striatus) ($n = 34$), Allegheny woodrat (Neotoma magister) ($n = 7$), and meadow jumping mouse (Zapus hudsonius) ($n = 1$). We found no significant difference in small mammal relative abundance or species richness between years ($F_{1,15} = 0.00$, $P = 0.9627$; $F_{1,15} = 5.48$, $P = 0.0793$) and among collection months ($F_{4,15} = 1.53$, $P = 0.2002$; $F_{4,15} = 2.49$, $P = 0.0567$). After combining year and month, no significant differences were found in small mammal relative abundance ($F_{3,15} = 0.63$, $P = 0.616$) or species richness ($F_{3,15} = 0.18$, $P = 0.909$) among mixtures (Table 2-6).

After combining years, there were significant differences among center, edge, and forest transects in both relative abundance ($F_{2,14} = 30.23$, $P < 0.0001$) and species richness ($F_{2,14} = 31.92$, $P < 0.0001$). Relative abundance and species richness on center transects were lower than both the edge and forest transects, and abundance and richness between forest and edge transects did not differ (Table 2-7).

4. Discussion

4.1. *Sediment*

Our findings suggest limited movement of sediments from log landings, regardless of vegetative cover (biomass and % cover present). Because our landings had little slope, these

findings may not be applicable where % slope exceeds 8.5%. Although posited as a contributing factor, we found no relation between amount of precipitation recorded and sediment collected on landings. Our estimates of sediment movement are likely somewhat higher than actually occurred over the landings because of our sediment well design. We observed less vegetation growing inside sediment wells than was growing outside of them. The closed box design and black silt fencing used to construct sediment wells may have caused increased temperatures inside wells and decreased soil moisture by channeling ground-flowing precipitation around the well area. Although reduced to 0.3 m in height, the silt fence caused a certain amount of shading inside sediment wells, thus contributing to the decreased vegetation growth within well areas. An alternative to our well design would be the use of a portable rainfall simulator to measure sediment flow from log landings. Although logistically more challenging, it would allow sediments to be collected more efficiently, more accurately, and less often (Mutchler et al. 1994).

Despite not finding substantial sediment movement from our log landings, re-vegetation remains important in preventing sediment movement after completion of logging, especially on more erosion-prone areas such as log landings with greater slopes, log road embankments and skid trails. Such areas have greater slopes than log landings and are problem areas for sediment loss. Grushecky et al. (2006) planted native vegetation on skid trails and log road embankments in the Upper Elk Watershed, West Virginia and reported a 92% and 58% reduction in sediment, respectively. Similarly, Grace (2000) planted exotic and native grasses on log road embankments in Alabama and observed a 66-98% sediment reduction immediately after vegetation establishment, and 100% sediment reduction 30 months after vegetation establishment. Swift (1984) reported minimized sediment movement to streams with prompt reseeding on log road embankments in the Southern Appalachian Mountains.

4.2. *Vegetation*

In an extensive forage quality study of commercial wildlife seed mixtures, Leep and Dietz (2006) found that the 20 resulting forages contained 20.8-29.3% ADF, 31.7-49.6% NDF, and 2.9-18.8% crude protein. Our forages contained 30.0-39.6% ADF (Table 2-3), which is much higher, and therefore less digestible than forages produced by the aforementioned commercial seed mixtures. Similarly, our forages contained higher levels of NDF (44.7-56.2%) than the commercial forages. Our plantings, unlike that by Leep and Dietz (2006), occurred on landings that had poor soil quality and vegetation that was not sampled at an optimal growth stage. It is widely accepted that wildlife seed mixtures should contain 12-20% crude protein for wildlife maintenance and production (Robbins 1993); our crude protein levels fell short of this mark. Crude protein was lower in our erosion and wildflower mixtures than in the traditional and wildlife mixtures (Table 2-3). These results suggest that although the traditional mixture is not native, it provides higher quality forage than our other seed mixtures. The presence of high quality forage species (e.g. white clover) in the traditional mixture contributed to this result.

We found biomass production was similar among native and traditional mixtures, suggesting that they were equal in stabilizing soil (Yahner 1992, Grace 2000) and providing cover and forage for wildlife. Several small mammal species prefer more complex, taller vegetation. In a study of small mammals living on reclaimed mine land, Hansen and Warnock (1978) found greater abundance of mammals living in taller vegetation. Our vegetation was tallest in the traditional and erosion mixtures (Table 2-4), making the native erosion mixture an acceptable alternative if vegetation height is important. Percent cover of vegetation is important in reducing soil movement (Yahner 1992, Grace 2000), as well as providing cover for small mammals. Bramble et al. (1992) found that small mammals were more abundant in areas with more

abundant vegetation cover in central Pennsylvania. Our percent cover was similar in the traditional mixture, erosion control, and wildlife mixtures (Table 2-4), suggesting that the erosion control and wildlife mixtures would make suitable alternative native mixtures if higher percent cover is important. A study by Anderson and Meikle (2006) found increased small mammal abundances in areas of forest vegetation with greater height and cover. Our erosion and wildlife mixtures are similar in height and % cover to the traditional mixture, making them suitable, native alternatives for erosion control and wildlife habitat enhancement.

To the best of our knowledge, there are no other studies comparing vegetation forage quality, biomass, height, and % cover on log landings to surrounding forest ground vegetation. However, Thill et al. (1990) found higher crude protein in the autumn and higher digestibility during summer and autumn in clear cut areas than in surrounding forests in central Louisiana. Similarly, we posited that planted vegetation on landings would provide higher quality forage, biomass, and % cover than existed in the surrounding forest; however, we found no differences in biomass, height, % cover, % ADF, and crude protein between forest ground vegetation and landing vegetation (Table 2-5). We speculate that the similarities can be attributed to the understory vegetation response to increased sunlight resulting from harvest. Basal area of forest stands on our study area was reduced by 43.6-58.1% following harvest (Table A-2). We also speculate that higher tannin content of forest vegetation may decrease the possible nutrition available to browsing wildlife in our forested plots (Ford et al. 1994), as vegetation high in tannins can tie up crude protein, making it unavailable for wildlife nutrition.

4.3. Small Mammals

Small mammal species assemblage that we recorded was similar to others reported in the region. Menzel et al. (1999) found masked shrews, smoky shrews, deer mice, southern red-

backed voles, pine voles, and woodland jumping mice living in wildlife openings and their surrounding forest habitats in the southern Appalachians. Buckner and Shure (1985) also reported high abundances of Peromyscus spp. in harvested openings in the southern Appalachian Mountains. Bramble and Yahner (1992) report similar species abundance and composition of small mammals on power line right-of-ways in central Pennsylvania.

Lower small mammal abundance and richness on our center transects relative to edge and forest transects was surprising, as our log landings were small in size (Table A-3) compared to forest openings described in the literature, suggesting their interior should be safer from predators and easier to access. However, small forest openings may not elicit a noticeable response in small mammal colonization and diversity (Yates et al. 1997, Menzel et al. 2005). Yahner (1986) and Menzel et al. (1999) suggest that forest openings leave small mammals vulnerable to predation, even if mast and cover are provided, which may account for our lower abundances on center transects. Unlike our study, higher abundances of small mammals were reported in forest openings created by logging than in the surrounding forest (Yahner 1992, Perry and Thill 2005). Yahner (1992) suggests that the abundance of low vegetation growing within forest openings contributes to the increased abundance. Diminished amounts of small mammals on center transects also may be related to the short duration since timber harvest, leaving only a short time for small mammals to colonize log landings. Buckner and Shure (1985) found Peromyscus spp. abundances surprisingly low in newly created forest openings, but found them to increase over time in forest openings up to 5 years post harvest.

Where habitat conditions (e.g., vegetation height and cover) were similar between edge and forest transects, we found no differences in relative abundance and species richness of small mammals. Sekgororoane and Dilworth (1995) reported small mammal abundance was highest

from edges of forest openings to 10 m into the forest. Menzel et al. (1999) suggest increases in coarse woody debris during landing construction and use may provide for similarities between edge and forest small mammal communities due to increased amounts created woody habitat on the edge.

Aside from Peromyscus spp., we expected to see several species of small mammal that select grassy, open areas colonizing our log landings. With the exception of one meadow vole and one meadow jumping mouse, such species did not colonize log landings during our study. Similarly, Adams and Geis (1983) found mainly deer mice and meadow voles in grassy right-of-ways in Virginia, North Carolina, South Carolina, Illinois, Oregon, and California. Parker et al. (1992) found that mainly opportunistic species, such as deer mice, chose to colonize forest openings planted in clover for wildlife. Lack of species colonizing grassy openings may have been a function of time, rather than habitat quality. Given more time, which may also lead to more vegetation growth and structure, it may be possible for more species of small mammals to colonize landings (Kirkland 1976). Lack of early successional species on our landings may also be a function of distance from source populations (Adams and Geis 1983). Most of our log landings were located several miles from early successional/grassland habitat, which likely decreased the likelihood of colonization.

5. Conclusions

We developed and assessed 3 native seed mixtures for log landing reclamation that would maintain sediment control, as well as enhance wildlife habitat. Our results suggest that although non-native traditional mixtures produce adequate physical structure to control sediment and provide wildlife habitat, native seeding mixtures can provide similar benefits in reclaimed areas affected by timber harvesting. This was a valuable pilot study to assess native seed mixtures for

reclamation and wildlife habitat enhancement. Future long-term studies on reclaiming log landings, skid trails, logging roads, and road embankments using native seed mixtures are necessary to gain more information on erosion control and the ecological benefits they can provide to wildlife.

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Table 2-1. Seed mixture composition and seeding rates used on planted log landings in the Upper Elk Watershed, West Virginia, 2005–2006 . Mixtures were spread at a rate of 5.1 kg/hectare (25 lb/acre).

Mixture	Common Name	Scientific Name	Rate (kg/hectare)	Percent
Erosion control	Annual winter wheat ^a	<i>Triticum aestivum L.</i>	2.0	40
	Creeping red fescue ^a	<i>Festuca rubra</i>	1.5	30
	Silky wild rye ^a	<i>Elymus villosus</i>	1.2	24
	Deer tongue grass ^a	<i>Panicum clandestinum, Tioga</i>	0.3	6
Wildlife	White clover ^b	<i>Trifolium repens, Ladino</i>	2.5	49
	Partridge pea ^a	<i>Chamaecrista fasciculata</i>	1.3	25
	Creeping red fescue	<i>Festuca rubra</i>	0.7	14
	Annual winter wheat	<i>Triticum aestivum L.</i>	0.5	10
	Deer tongue grass	<i>Panicum clandestinum, Tioga</i>	0.1	2
	Wild blackberry ^a	<i>Rubus allegheniensis</i>	0.02	1
Wildflower	Black-eyed Susan ^a	<i>Rudbeckia hirta</i>	1.1	21
	Annual winter wheat	<i>Triticum aestivum L.</i>	1.0	20
	Creeping red fescue	<i>Festuca rubra</i>	0.8	15
	Silky wild rye	<i>Elymus villosus</i>	0.6	12
	Showy tick trefoil ^a	<i>Desmodium canadense</i>	0.5	10
	Wild blue lupine ^a	<i>Lupinus perennis</i>	0.5	10
	Ox eye sunflower ^a	<i>Heliopsis helianthoides</i>	0.3	5
	New England aster ^a	<i>Aster novae-angliae</i>	0.2	4
	Deer tongue grass	<i>Panicum clandestinum, Tioga</i>	0.2	3
Traditional	Orchard grass ^c	<i>Dactylis glomerata L.</i>	1.0	20
	Perennial ryegrass ^c	<i>Lolium perenne L.</i>	1.0	20
	Rye grain ^c	<i>Secale cereale</i>	0.5	10
	Timothy grass ^c	<i>Phleum pratense</i>	0.5	10
	Red clover ^c	<i>Trifolium pratense</i>	0.8	16
	Birdsfoot trefoil ^c	<i>Lotus corniculatus L.</i>	0.7	14
	Unknown seed		0.5	10

^aNative in Appalachians

^bNaturalized

^cExotic

Table 2-2. Vegetation biomass among seed mixtures planted on log landings in the Upper Elk Watershed, West Virginia, 2005–2006. Vegetation biomass was assessed inside exclosures and paired non-exclosures plots.

Seed mixture	Exclosure ^a			Paired-plot ^a		
	Mean	n	SE	Mean	n	SE
Erosion control	29.3	5	30.0	24.2	5	16.0
Wildlife	21.7	5	4.1	15.2	5	5.8
Wildflower	19.5	5	9.9	11.8	5	8.3
Traditional	38.1	5	11.5	29.7	5	4.7

^aANOVA found no overall difference in biomass production between exclosures and paired plots ($F_{4, 13} = 0.61$, $P = 0.659$).

Table 2-3. Vegetation forage quality among seed mixtures planted on log landings in the Upper Elk Watershed, West Virginia, 2005–2006.

Mixture	Forage Quality								
	% NDF ^a			% ADF			% Crude Protein		
	Mean ^{bc}	n	SE	Mean ^c	n	SE	Mean ^c	n	SE
Erosion control	56.2 a	9	2.2	34.6 a	9	1.3	9.5 b	9	2.1
Wildlife	44.7 a	10	1.5	30.6 a	10	1.0	14.0 a	10	1.4
Wildflower	51.2 a	9	1.7	40.0 a	9	1.9	9.0 b	9	0.6
Traditional	47.6 a	10	8.4	33.5 a	10	1.1	14.6 a	10	0.8

^a Percentage variables were arcsine square root transformed before ANOVA; untransformed data presented in table.

^b Means within columns followed by different letters within indicate a significant difference from one another (Tukey-Kramer Least Squared Means adjustment for multiple comparisons, $P \leq 0.05$).

^c ANOVA Results: % NDF ($F_{3,9} = 1.95$, $P = 0.144$); % ADF ($F_{3,9} = 0.65$, $P = 0.590$); % Crude Protein ($F_{3,9} = 3.9$, $P = 0.0003$)

Table 2-4. Vegetation height (cm) and percent cover on log landings planted with native seed mixtures in the Upper Elk Watershed located in West Virginia, 2005–2006.

Mixture	Vegetation Structure					
	Height (cm)			% Cover ^a		
	Mean ^b	n	SE	Mean	n	SE
Erosion control	9.0 a	5	3.6	44.3 a	5	17.2
Wildlife	6.3 ab	5	1.5	59.5 b	5	8.0
Wildflower	5.7 b	5	2.5	43.7 a	5	14.2
Traditional	12.0 a	5	2.9	85.5 c	5	6.1

^a Percentage variables were arcsine square root transformed before ANOVA; untransformed data presented in table.

^b Means within columns followed by different letters indicate a significant difference from one another (Tukey-Kramer Least Squared Means adjustment for multiple comparisons, $P \leq 0.05$).

Table 2-5. Comparison of understory vegetation characteristics on log landings and in surrounding forest plots in the Upper Elk Watershed, West Virginia, July 2006.

	Forest vegetation			Landing vegetation			t-value	<i>P</i> > <i>t</i>
	Mean	n	SE	Mean	n	SE		
Biomass (g/m ²)	20.4	12	1.7	39.2	12	10.6	-1.80	0.0990
Height (cm)	13.0	12	1.8	10.6	12	1.9	1.15	0.2727
% Cover ^a	59.0	12	8.5	72.1	12	8.5	-1.12	0.2847
% NDF	46.0	12	2.5	54.0	12	2.0	-2.82	0.0166
% ADF	35.3	12	1.5	35.9	12	1.6	-0.36	0.7288
% Crude Protein	10.9	12	0.6	12.1	12	1.1	-1.11	0.2919

Table 2-6. Mean relative abundance (mammals/100 trap nights) and species richness (#species/mixture) of small mammals trapped on center and edge transects of log landings planted with native seed mixtures in the Upper Elk Watershed, West Virginia, 2005–2006.

Year	Mixture	Relative abundance			Species richness		
		Mean ^a	n	SE	Mean	n	SE
2005	Erosion control	15.5	2	10.5	3.0	2	1.0
	Wildlife	9.0	2	0.0	4.0	2	1.0
	Wildflower	7.0	2	4.0	2.0	2	0.0
	Traditional	9.5	2	2.5	3.5	2	0.5
2006	Erosion control	9.7	3	4.1	3.7	3	1.5
	Wildlife	9.0	3	2.1	3.7	3	0.7
	Wildflower	10.3	3	4.4	3.0	3	0.6
	Traditional	13.3	3	1.2	6.0	3	1.0
Combined	Erosion control	7.0	5	2.5	3.4	5	0.9
	Wildlife	10.2	5	1.1	3.8	5	0.5
	Wildflower	10.6	5	2.8	2.6	5	0.4
	Traditional	11.8	5	1.4	5.0	5	0.8

Table 2-7. Mean relative abundance (mammals/100 trap nights) and species richness (#species/mixture) of small mammals trapped on and near log landings planted with native seed mixtures in the Upper Elk Watershed, West Virginia, 2005–2006.

Transect	Relative abundance			Species richness		
	Mean ^a	n	SE	Mean	n	SE
Center	5.2 a	20	1.0	1.6 a	20	0.2
Edge	16.2 b	20	1.9	3.3 b	20	0.3
Forest	17.6 b	20	2.1	4.1 b	20	0.4

^a Means within columns followed by different letters indicate a significant difference from one another (Tukey-Kramer Least Squared Means adjustment for multiple comparisons ($P \leq 0.05$))

Figure 2-1. Locations of log landings seeded with traditional and native seed mixtures in the Upper Elk Watershed, West Virginia, 2005–2006.

Figure 2-2. Modified ripper-tooth assembly used to scarify log landings prior to planting with native seed mixtures in the Upper Elk Watershed, West Virginia, 2005–2006.

Figure 2-3. Silt fence sediment well design and setup for sediment collection on log landings planted with native seed mixtures in the Upper Elk Watershed, West Virginia, 2005–2006.

Figure 2-4. Vegetation clipping enclosure and paired-plot design for vegetation assessment on log landings planted with native seed mixtures in the Upper Elk Watershed, West Virginia, 2005–2006.

— = Landing Perimeter

1 = Center Transect

2 = Edge Transect

3 = Forested Transect

Figure 2-5. Small mammal trapping transect array used on log landings planted with native seed mixtures in the Upper Elk Watershed, West Virginia, 2005-2006.

Chapter 3

A Compromise Programming Approach to Evaluate Seed Mixtures Used to Reclaim Log Landings

A COMPROMISE PROGRAMMING APPROACH TO EVALUATE SEED MIXTURES USED TO RECLAIM LOG LANDINGS²

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Abstract

We used compromise programming analysis to find the best of 4 seed mixtures for reclaiming log landings based on land management objectives. Objectives used for analysis included those of a private landowner interested in hunting, a private landowner interested in aesthetics, a timber company, and a wildlife manager. We used % crude protein, vegetation biomass (g/m^2), vegetation height (cm), vegetation percent cover (% vegetated ground/ m^2), % sediment reduction (compared to non-vegetated ground), small mammal relative abundance (number of captures/100 trap nights), small mammal species richness (number of species/mixture), and seed mixture cost (dollars/ha) as criteria for our compromise programming analysis. We ranked and weighted each criterion based on landowner objectives. The seed mixture with the lowest compromise programming value in each objective was considered the most ideal mixture. Among native mixtures, the wildlife mixture had the lowest compromise programming value for all land manager objectives. The non-native traditional mixture had the lowest compromise programming value among all mixtures.

² Chapter formatted in the Journal of Forest Ecology and Management style

1. Introduction

Forest roads, skid trails, and log landings contribute to non-point source pollution entering streams and rivers (Egan et al. 1996, National Association of State Foresters 2001). Best Management Practices (BMPs), initiated in West Virginia in 1972, state that once a logging site is retired, timber companies are required to “reclaim” skid trails and log landings by grooming, mulching, and reseeded to reduce or prevent erosion (West Virginia Division of Forestry 2005) (Fig. A-2). Prompt reseeded following logging establishes vegetation and stabilizes the soil to minimize non-point source pollution. When properly followed, BMPs reduce non-point source pollution resulting from logging activities (National Association of State Foresters 2001, Vowell 2001, Edwards 2002). BMP timber-harvesting guidelines protect water quality by minimizing erosion and sedimentation. However, there has been an increased awareness in recent years for BMPs not only to maintain water quality, but also to protect and enhance habitat for wildlife (Ice et al. 1997, National Association of State Foresters 2001, Edwards 2002). In the Appalachian region, this has lead to an increase in planting and maintenance of forest openings created by timber harvesting to enhance wildlife habitat (Wentworth et al. 1990).

Forest openings, unlike mature or thinned forests, are generally maintained in herbaceous grasses and woody shrubs, making them early successional habitat. Such, early successional vegetation provides low woody habitat, soft mast, forage for browsing wildlife, and nesting opportunities, among other beneficial qualities. Forest openings provide edge and travel corridors, as well as greater habitat and plant species diversity which is not usually present in a mature forest (Parker et al. 1992). Although the benefits of forest openings for wildlife have been well documented (Thill et al. 1990, Harley 1991, Menzel et al. 1999, Costello et al. 2000,

Ross et al. 2000), few studies have examined the importance of planting native vegetation in forest openings to enhance wildlife habitat.

Traditionally, loggers and foresters follow BMP guidelines by reseeding retired landings with inexpensive grasses that quickly provide erosion control. However, these grasses are typically not native nor do they provide high quality forage or soft mast for wildlife. Planting non-native vegetation may decrease erosion, but it does not promote native vegetation or wildlife communities (Holl 2002). Although planting non-native species has become common practice, their impacts on the environment and surrounding plant and animal communities should be considered before they are introduced (Daehler and Gordon 1997). Concern for wildlife health and a desire for native plantings have created a need for native reclamation seed mixtures that maintain erosion control and enhance wildlife habitat.

Native herb and shrub alternatives are available and may provide adequate erosion control, enhanced habitat, and aesthetic benefits; however, there has been little research to support the planting of these native species. Our study focused on selecting a native seed mixture that would maintain erosion control, while best satisfying individual land manager objectives. Land managers not only have differing objectives for choosing a reclamation mixture, but they also must choose a seed mixture based on several different criteria (e.g., vegetation height, forage quality, cost, native vs. non-native, etc.).

Compromise programming is a multi-criteria decision-making approach that allows managers to assess several criteria (e.g., height, biomass, forage quality, etc.) used to measure different alternatives (e.g., different seed mixtures), and give each criterion a weight of importance (Tkach and Simonovic 1997) based on different objectives. A compromise programming distance metric (CP metric) is calculated for each alternative. The CP metric is the

mathematical distance between the ideal solution that the decision maker is striving for and the alternative being analyzed. The alternative with the lowest resulting CP metric is considered closest to the ideal solution, making it the most optimal solution (Zeleny 1973, Teclé et al. 1988, Pereira and Duckstein 1993, Tkach and Simonovic 1997). Consequently, our objective was to use compromise programming to find the best native seed mixture among 3 alternatives for reclaiming log landings, based on the hypothetical objectives of a private landowner interested in hunting, a private landowner interested in aesthetics, a timber company, and a wildlife manager. For comparison, we also included a non-native, traditional seed mixture commonly used for reclamation by timber companies.

2. Methods

Tager et al. (2007; Chapter 2) developed 3 native seed mixtures for reclaiming log landings in the Appalachian region and compared their success in reducing erosion and enhancing wildlife habitat to a commonly used traditional seed mixture containing primarily non-native species. Species composition of the 4 seed mixtures varied as follows: (1) erosion control mixture consisted of annual winter wheat (Triticum aestivum L.), creeping red fescue (Festuca rubra), silky wild rye (Elymus villosus), and deer-tongue grass (Panicum clandestinum, Tioga); (2) wildlife mixture consisted of ladino clover (Trifolium repens, Ladino), partridge pea (Chamaecrista fasciculata), creeping red fescue, annual winter wheat, deer tongue grass, and wild blackberry; (3) wildflower mixture consisted of black-eyed Susan (Rudbeckia hirta), annual winter wheat, creeping red fescue, silky wild rye, showy tick trefoil (Desmodium canadense), wild blue lupine (Lupinus perennis), ox eye sunflower (Heliopsis helianthoides), and New England aster (Aster novae-angliae); and (4) traditional mixture contained orchard grass (Dactylis glomerata L.), perennial ryegrass (Lolium perenne L.), rye grain (Secale cereale),

timothy grass (Phleum pratense), red clover (Trifolium pratense), birdsfoot trefoil (Lotus corniculatus L.), and trace amounts of various unknown seeds (Table 2-1). All seed mixtures, except for the traditional mixture, contained only native and naturalized (Ladino clover) species of plants.

We used a compromise programming approach to evaluate which seed mixture was best at satisfying differing land management objectives. Our analysis included 4 hypothetical landowner/manager categories: (1) a private landowner interested in hunting, (2) a private landowner interested in aesthetics, (3) a timber company, and (4) a wildlife manager. We also included a fifth, category representing a generic landowner with no specific land management objectives (i.e., no weighting of criteria). We used the following criteria: % crude protein (CP), vegetation biomass (g/m^2), vegetation height (cm), vegetation percent cover (% vegetated ground/ m^2), % sediment reduction (compared to non-vegetated ground), small mammal relative abundance (number of captures/100 trap nights), small mammal species richness (number of species/mixture), and seed mixture cost (dollars/ha) (Tager 2007; Chapter2). We weighted criterion for each category using the rank sum method (Malczewski 1999). Each criterion was given a rank of 1–10 (most important–least important), based on their relative importance compared to other criteria (Kremer et al. 2005). Ranking allowed us to express the varying views towards each criterion based on differing landowner/manager objectives. If equal in importance, several criteria received the same rank, and criteria that were considered unimportant were given a rank of 0 (Malczewski 1999).

Ranking of criteria for land manager objectives varied as follows: (1) for the landowner interested in hunting we weighted % CP highest because it provides protein for wildlife maintenance and production; native vs. non-native 2nd because maintaining native plants helps to

maintain healthy wildlife habitat; small mammal relative abundance, vegetation height, % cover, and vegetation biomass 3rd because small mammals are an important food source to carnivores and vegetation is important to herbivores; and cost, sediment reduction, and showy flowers 4th–6th, respectively; (2) for the landowner interested in aesthetics, we ranked % showy flowers, vegetation % cover, and vegetation height 1st–3rd because they all affect the aesthetic quality of vegetation; and cost, sediment reduction and native vs. non-native 4th; (3) timber company rankings only included cost, which was ranked highest, and vegetation percent cover and sediment reduction. We chose these ranks because a timber company is mainly interested in getting vegetation to grow successfully to control erosion (reduce sediment) at a reasonable cost. All other criteria for the timber company objective were given a rank of 0; and (4) for the wildlife manager we ranked % CP highest because of the desire for high quality forage, as well as native vs. non-native vegetation because a wildlife manager would ideally see the value in preserving native plant populations on their land; small mammal abundance and richness were ranked 2nd because the abundance and diversity of small mammals represent a healthy habitat and overall wildlife diversity; cost was ranked 3rd because a wildlife manager would most likely be working on a restricted budget; and we ranked biomass, % showy flowers, % cover, sediment reduction, and vegetation height 4th–8th, respectively, due to their structural, environmental, and wildlife related importance (Table 3-1).

Once rankings were established, we generated normalized weights using the following rank sum equation (Malczewski 1999) (Table 3-1):

$$W_j = (n-r_j)/\sum(n-r_k+1)$$

Where:

$$W_j = \text{normalized weight for } j^{\text{th}} \text{ criterion}$$

n = number of criterion under consideration ($k = 1, 2, \dots, n$)

r_j = rank position of each criterion

A matrix of seed mixtures vs. criteria measurements was constructed (Teclé and Yitayew 1990) (Table 3-2). We standardized matrix values from 0–1 based on the relative deviation from the ideal level of each criterion (Marshall and Homans 2004) because some criteria were measured using different units (Pereira and Duckstein 1993, Beromeu and Romero 2002). We calculated the CP metric, or distance from the ideal value, for each criterion in each seed mixture using the following equation (Teclé and Yitayew 1990):

$$\text{CP metric} = \text{Min} \{ L_p(A_i) - [\sum (W_i) [(f_i^* - f_g) / (f_i^* - f_i^{**})]^p]^{1/p} \}$$

Where:

$L_p(A_i)$ = distance metric

W_i = standardized criterion weight, decision maker's preference

f_i^* = maximum/ideal value for criterion

f_i^{**} = minimum/worst value for criterion

Criterion CP metrics were summed for each seed mixture, and the mixture with the lowest CP metric value was considered the closest solution to the ideal for each category. To get the most accurate, satisficing solution for each category a p-value of 1, 2, and 10 for all weight sets.

Often, a p-value of 1 will find the most accurate solution; however, using 2 and 10 as p-values can sometimes reveal more exact solutions as the compromise programming equation exponentially more accurate (Zeleny 1973). A p-value of 10 is the highest recommended value for compromise programming, as p-values > 10 do not usually increase accuracy (Pereira and Duckstein 1993).

3. Results

Among native mixtures, the wildlife mixture had the lowest CP metric for all objectives at all p-values, therefore making it the best native mixture for satisfying any of our hypothetical objectives of land managers (Table 3-3). The traditional mixture was the best overall seed mixture at all p-values for all objectives, except in the aesthetic landowner category, where the wildlife mixture was best at $p = 10$. However, upon reviewing results, it is clear that the difference between the native wildlife mixture and non-native traditional mixture is small, particularly at higher p-values (Table 3-3). The highest CP metric, and therefore least desirable mixture, for all objectives and p-values was the wildflower mixture (Table 3-3).

4. Discussion

Our compromise programming analysis indicated that the traditional mixture, although not native, was the most ideal seed mixture for each land manager objective, including the generic objective. This indicates that timber companies planting the traditional mixture use a combination of plant species that are successful at maintaining erosion control, are cost effective, provide enhanced wildlife habitat, and are aesthetically pleasing. However, the main goal of our study was to find a *native* seed mixture that would provide erosion control and satisfy different land management objectives. We expected our generic weighting to yield different results than other land manager objectives; however, it followed a similar trend to all other objectives. We hypothesized that the wildlife mixture would be best native mixture at satisfying our hunting landowner and wildlife manager objectives, because it was high in crude protein and had the most desirable vegetation and small mammal population characteristics. Our findings supported this hypothesis. For the wildlife manager and hunting landowner objectives, this is a positive outcome because the wildlife seed mixture was formulated specifically to enhance wildlife

habitat. At the highest p-value ($p = 10$), the traditional mixture and wildlife mixture produced similar CP metric values, and therefore would be considered equally desirable alternatives.

We also hypothesized that the wildflower mixture would be the best native mixture for our aesthetic landowner objective due to its abundance of species producing showy flowers. However, we found the wildlife mixture also was the best native mixture for the aesthetic landowner. We attribute this difference to the lack of wildflower vegetation growth (biomass and % cover), and the unexpected abundance of showy flowers in the wildflower mixture (e.g., partridge pea, white clover). Because of its lack of successful growth, the wildflower mixture was the least desirable among mixtures.

Among native mixtures, we hypothesized that the erosion control mixture would best satisfy the timber company objective. However, the wildlife mixture was found most desirable native mixture for the timber company objective. We attribute this outcome to the less successful growth of vegetation (biomass and % cover) in the erosion control mixture in comparison to the wildlife mixture. Although the wildlife mixture is better at meeting the objectives of the timber company, from a purely economical standpoint, its cost may be prohibitive (66% more expensive than the traditional mixture).

In this study, we analyzed several different land owner objectives separately. Kremer et al. (2005) used a similar approach to look at differing forest management goals based on economic, carbon, and structural objectives, allowing them to avoid sources of conflict among different land managers (Kremer et al. 2005). However, a compromise programming analysis can also be used to make land management decisions when different land management objectives must be accounted for simultaneously. A study examining the design of bioreserve networks by Rothley (1999) used several different demands and objectives to find the most

satisfying solution for different groups involved in the project, including reserve planners and public using the reserve for recreation.

Though our analysis was informative, it would be useful to do a similar analysis that attempts to combine the objectives of several different landowners into one analysis. Additionally, native seed mixtures can be added to future analyses as they are developed and studied. The approach we used included four broad objectives with different weight sets. However, land managers that have similar objectives, may choose different weights of importance, or even criteria, for their compromise programming analysis, making their results different from ours. Hence, the ability of different land managers to manage land as a unit (Teale et al. 1987) with varying objectives makes compromise programming a beneficial tool. This type of analysis may prove helpful to future land management studies attempting to combine the similar goals such as wildlife habitat enhancement, erosion control, native grass use in reclamation, and other land management objectives.

5. Conclusions

Compromise programming analysis was used to find the best of 3 native seed mixtures for reclaiming log landings based on different land management objectives. To our best knowledge, there have been no similar studies examining reclamation mixtures using compromise programming, making this a unique analysis. The largest criticism of compromise programming is that weights assigned by the decision maker may be bias and subjective (Buchanan et al. 2004). However, if decision makers remain objective, compromise programming can be a very accurate tool. Compromise programming, and multi-criteria decision making as a whole, proved useful to this study, as our results strengthen the argument

that native seed mixtures are able to simultaneously provide erosion control, wildlife habitat enhancement, and other land management objectives on harvested land.

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Table 3-1. Normalized weights and justifications for 5 different objectives used in a compromise programming analysis of traditional and native seed mixtures planted on log landings in the Upper Elk Watershed located in West Virginia, 2005–2006. Weights were determined using a rank sum method.

Criteria	Generic	Landowner (hunter)	Landowner (aesthetic)	Timber company	Wildlife Manager
Small mammal relative abundance (#captures/100 trap nights)	0.100	0.100 more small mammals=more predators	0.000 not trying to benefit wildlife	0.000 not trying to benefit wildlife	0.125 more small mammals=good habitat health
Small mammal species richness (#species/mixture)	0.100	0.000 small mammal diversity not as important as abundance to a hunter	0.000 not trying to benefit wildlife	0.000 not trying to benefit wildlife	0.125 higher small mammal diversity=higher overall wildlife diversity
Vegetation height (cm)	0.100	0.100 greater height=greater structure for wildlife	0.150 height looks more pleasing	0.000 height is not important to erosion control	0.060 greater height= greater structure for wildlife
Vegetation % Cover (%vegetated ground/m ²)	0.100	0.100 greater vegetative cover=more forage & more cover	0.250 more cover looks more pleasing; bare ground looks poor	0.300 greater cover=better erosion control	0.070 greater vegetative cover=more forage & more cover
Vegetation biomass (g/ m ²)	0.100	0.100 more biomass=more forage	0.000 as long as area looks covered, biomass is unimportant	0.000 as long as area has good cover, biomass is unimportant	0.080 more biomass=more forage
% Crude Protein	0.100	0.200 %CP is often most important part of forage quality	0.000 not trying to benefit wildlife	0.000 not trying to benefit wildlife	0.150 most important aspect of forage quality
% Sediment reduction (compared to non-vegetated ground)	0.100	0.090 landowner will want to reduce erosion, but might not find it as important as other land managers	0.100 landowner will want to reduce erosion, but it will not be as important as aesthetics	0.300 main goal is to reduce sediment by planting	0.065 needs to be considered since erosion can affect stream wildlife

Table 3-1. Continued

Criteria	No weights	Landowner (hunter)	Landowner (aesthetic)	Timber company	Wildlife Manager
Cost/ha (\$)	0.100	0.095 hunter may be willing to spend more than other land managers	0.100 planting for aesthetics can get expensive, but landowner may be willing to spend more to get good results	0.400 looking for the most cost effective mixture that grows well to reduce erosion	0.100 limited funds for wildlife management makes cost important
% Showy flowers (% composition of overall mixture)	0.100	0.065 showy flowers attract insects and other wildlife	0.300 most important criterion for a landowner interested in aesthetics	0.000 only goal is to reduce sediment	0.075 showy flowers attract insects and other wildlife
Native vs. non-native	0.100	0.150 forage quality is more important than native; but using native species does maintain healthy wildlife habitat and biodiversity	0.100 if exotics/non-natives are planted, they may take over and destroy aesthetics	0.000 As long as mixture grows well and reduces sediment cheaply, nativity does not matter	0.150 using native species maintains healthy forest and wildlife communities and biodiversity

Table 3-2. Compromise programming matrix of different seed mixtures planted on log landings in the Upper Elk Watershed, West Virginia, 2005–2006. Values represented in the matrix are raw data collected prior to normalization and compromise programming analysis by Tager et al. (2007; Chapter 2).

Criteria	Seed mixtures			
	Erosion	Traditional	Wildlife	Wildflower
Small mammal relative abundance (#captures/100 trap nights)	14.0	14.2	10.2	10.6
Small mammal species richness (#species/mixture)	4.6	5.6	4.8	4.2
Vegetation height (cm)	9.0	12.0	6.3	5.7
Vegetation % Cover (%vegetated ground/m ²)	44.3	85.5	59.5	43.7
Vegetation biomass (g/ m ²)	29.3	38.1	21.7	19.5
% Crude protein	9.0	14.6	14.0	9.3
% Sediment reduction (compared to bare ground)	43.7	85.7	75.7	27.6
Cost (\$)/ha	82.4	67.4	169.6	378.0
% Showy flowers (% composition of overall mixture)	0.0	0.3	0.5	0.8
Native vs. non-native (1 = yes; 0 = no)	1.0	0.0	1.0	1.0

Table 3-3. Compromise programming results with p-value = 1, 2, and 10 and different land manager objectives for seed mixtures planted on log landings in the Upper Elk Watershed, West Virginia, 2005–2006. Values in bold indicate mixtures with the lowest compromise programming metric, making them the closest, most ideal mixture for land manager objectives. Values in italics indicate the best *native* mixture for land manager objectives.

Seed mixture	p-value	Generic	Landowner (hunter)	Landowner (aesthetic)	Timber company	Wildlife manager
Erosion control	1	0.55	0.54	0.70	0.53	0.51
Wildlife		<i>0.49</i>	<i>0.44</i>	<i>0.44</i>	<i>0.37</i>	<i>0.45</i>
Wildflower		0.78	0.74	0.60	1.00	0.75
Traditional		0.17	0.21	0.30	0.00	0.20
Erosion control	2	0.67	0.68	0.79	0.67	0.65
Wildlife		<i>0.60</i>	<i>0.57</i>	<i>0.52</i>	<i>0.41</i>	<i>0.57</i>
Wildflower		0.88	0.85	0.77	1.00	0.86
Traditional		0.38	0.44	0.48	0.00	0.43
Erosion control	10	0.88	0.91	0.94	0.88	0.88
Wildlife		<i>0.84</i>	<i>0.84</i>	0.76	<i>0.55</i>	<i>0.84</i>
Wildflower		0.96	0.95	0.95	1.00	0.95
Traditional		0.80	0.83	0.80	0.00	0.83

Table A-1. Small mammal habitat preferences for species known to occur in the Upper Elk Watershed, West Virginia (Browsers et al. 2004).

Species	Common Name	Habitat
<i>Blarina brevicauda</i>	Northern short-tailed shrew	forest to clearings with dense ground cover
<i>Clethrionomys gapperi</i>	Southern red-backed vole	mesic forests, thickets, and meadows; prefer areas with log and stump clutter
<i>Microtus pennsylvanicum</i>	meadow vole	fields and grasslands
<i>Microtus pinetorum</i>	woodland vole	mesic deciduous and mixed forest with abundant leaf litter
<i>Napaeozapus insignis</i>	woodland jumping mouse	forests with dense understory
<i>Neotoma magister</i>	Allegheny woodrat	rock outcroppings in forests with abundant mast
<i>Peromyscus leucopus</i>	white-footed deer mouse	forests, farmland, brushland, and meadows
<i>Peromyscus maniculatus</i>	deer mouse	deep forest to open fields
<i>Sorex cinereus</i>	masked shrew	moist habitats with dense low cover
<i>Sorex fumeus</i>	smoky shrew	mesic forests
<i>Tamias striatus</i>	Eastern chipmunk	deciduous forests
<i>Zapus hudsonius</i>	meadow jumping mouse	open fields and forests with dense undergrowth

Table A-2. Table of trees/ha and basal area (m²/ha) for forested areas surrounding log landings planted with native and traditional seed mixtures in the Upper Elk Watershed, West Virginia, 2006.

	Overstory (>12.7 cm dbh)			Midstory (2.5-12.45 cm dbh)		
Site ID	Species	Trees/ha	Basal area (m ²)/ha	Species	Trees/ha	Basal area (m ²)/ha
1A	<i>Acer rubrum</i>	49.40	2.24	<i>Acer rubrum</i>	82.33	0.35
	<i>Acer saccharum</i>	16.47	2.74	<i>Acer saccharum</i>	411.67	0.17
	<i>Betula lenta</i>	41.17	2.63	<i>Fagus grandifolia</i>	82.33	0.09
	<i>Carpinus caroliniana</i>	8.23	1.97			
	<i>Carya spp.</i>	8.23	1.86			
	<i>Fagus grandifolia</i>	57.63	3.77			
	<i>Fraxinus americana</i>	8.23	6.01			
	<i>Juglans nigra</i>	8.23	1.38			
	<i>Liriodendron tulipifera</i>	57.63	6.52			
	<i>Quercus alba</i>	16.47	6.06			
	<i>Quercus rubra</i>	16.47	2.40			
Totals:	288.17	25.27		576.33	1.76	
1B	<i>Acer rubrum</i>	57.63	3.26	<i>Fagus grandifolia</i>	658.67	2.19
	<i>Betula lenta</i>	16.47	0.35	<i>Nyssa sylvatica</i>	82.33	0.28
	<i>Carya spp.</i>	16.47	1.08	<i>Robinia pseudoacacia</i>	82.33	0.96
	<i>Fagus grandifolia</i>	107.03	3.49			
	<i>Liriodendron tulipifera</i>	41.17	3.31			
	<i>Magnolia accuminata</i>	16.47	1.89			
	<i>Quercus rubra</i>	8.23	0.68			
	<i>Robinia pseudoacacia</i>	8.23	0.19			
Totals:	271.70	14.24		823.33	3.44	

Table A-2. Continued

Site ID	Overstory (>12.7 cm dbh)			Midstory (2.5-12.45 cm dbh)		
	Species	Trees/ha	Basal area (m ²)/ha	Species	Trees/ha	Basal area (m ²)/ha
1C	<i>Acer saccharum</i>	65.87	0.91	<i>Acer saccharum</i>	82.33	0.81
	<i>Betula alleghaniensis</i>	24.70	0.67			
	<i>Betula lenta</i>	82.33	1.31			
	<i>Carya spp.</i>	8.23	0.69			
	<i>Fagus grandifolia</i>	16.47	0.64			
	<i>Fraxinus americana</i>	32.93	0.51			
	<i>Liriodendron tulipifera</i>	82.33	0.88			
	<i>Pinus strobus</i>	74.10	0.97			
	<i>Quercus rubra</i>	8.23	0.91			
	Totals:	395.20	21.59		82.33	0.81
1D	<i>Acer rubrum</i>	24.70	1.16	<i>Acer rubrum</i>	741.00	4.24
	<i>Liriodendron tulipifera</i>	117.33	4.56	<i>Fagus grandifolia</i>	370.50	1263.51
	<i>Magnolia fraseri</i>	6.18	0.21	<i>Liriodendron tulipifera</i>	802.75	27.76
	<i>Nyssa sylvatica</i>	24.70	0.64	<i>Magnolia accuminata</i>	61.75	0.09
	<i>Quercus prinus</i>	37.05	2.58	<i>Nyssa sylvatica</i>	185.25	3.58
	<i>Quercus rubra</i>	12.35	1.55	<i>Quercus prinus</i>	185.25	19.59
	<i>Quercus velutina</i>	6.18	0.78	<i>Robinia pseudoacacia</i>	61.75	1.62
	<i>Robinia pseudoacacia</i>	6.18	0.37			
	Totals:	234.65	11.85		2408.25	67.80

Table A-2. Continued

Site ID	Overstory (>12.7 cm dbh)			Midstory (2.5-12.45 cm dbh)		
	Species	Trees/ha	Basal area (m ²)/ha	Species	Trees/ha	Basal area (m ²)/ha
2B	<i>Acer rubrum</i>	24.70	1.78	<i>Acer rubrum</i>	61.75	0.13
	<i>Acer saccharum</i>	61.75	1.68	<i>Acer saccharum</i>	432.25	1.75
	<i>Carya spp.</i>	12.35	0.81	<i>Fagus grandifolia</i>	61.75	0.21
	<i>Fagus grandifolia</i>	37.05	3.74	<i>Liriodendron tulipifera</i>	802.75	5.50
	<i>Liriodendron tulipifera</i>	148.20	8.87	<i>Quercus rubra</i>	61.75	0.55
	<i>Platanus occidentalis</i>	6.18	1.56	<i>Robinia pseudoacacia</i>	185.25	1.04
	<i>Quercus alba</i>	6.18	2.15			
	<i>Quercus rubra</i>	92.67	4.09			
	<i>Robinia pseudoacacia</i>	37.05	1.20			
	Totals:	364.33	24.20		1605.50	9.18
3A	<i>Acer rubrum</i>	12.35	0.45	<i>Acer saccharum</i>	123.50	1.11
	<i>Acer saccharum</i>	30.92	1.52			
	<i>Betula alleghaniensis</i>	12.35	0.75			
	<i>Betula lenta</i>	30.88	1.83			
	<i>Carya spp.</i>	12.35	0.87			
	<i>Fagus grandifolia</i>	49.40	1.83			
	<i>Fraxinus americana</i>	6.18	0.71			
	<i>Liriodendron tulipifera</i>	92.63	9.21			
	<i>Magnolia fraseri</i>	6.18	0.45			
	<i>Pinus strobus</i>	55.58	2.83			
	<i>Prunus serotina</i>	6.18	0.23			
	<i>Quercus prinus</i>	18.53	1.43			
	<i>Quercus rubra</i>	30.88	3.38			
	Totals:	364.33	25.50		123.50	1.11

Table A-2. Continued

Site ID	Overstory (>12.7 cm dbh)			Midstory (2.5-12.45 cm dbh)		
	Species	Trees/ha	Basal area (m ²)/ha	Species	Trees/ha	Basal area (m ²)/ha
3B	<i>Acer rubrum</i>	8.23	0.88	<i>Acer saccharum</i>	329.33	0.92
	<i>Acer saccharum</i>	32.93	1.39	<i>Carpinus caroliniana</i>	82.33	0.08
	<i>Betula lenta</i>	8.23	0.59	<i>Fagus grandifolia</i>	82.33	0.07
	<i>Fagus grandifolia</i>	8.23	1.14	<i>Juglans nigra</i>	82.33	0.15
	<i>Juglans nigra</i>	82.33	4.15			
	<i>Liriodendron tulipifera</i>	115.27	13.32			
	<i>Ulmus americana</i>	8.23	0.21			
	Totals:	263.47	21.67		576.33	1.22
3D	<i>Acer rubrum</i>	55.58	2.97	<i>Acer saccharum</i>	432.25	1.27
	<i>Acer saccharum</i>	30.88	0.76	<i>Betula lenta</i>	123.50	1.28
	<i>Betula lenta</i>	43.23	1.49	<i>Carpinus caroliniana</i>	123.50	0.21
	<i>Carya spp.</i>	6.18	0.23	<i>Fagus grandifolia</i>	185.25	0.42
	<i>Fagus grandifolia</i>	74.10	3.71	<i>Quercus rubra</i>	61.75	0.55
	<i>Fraxinus americana</i>	37.05	1.18			
	<i>Liriodendron tulipifera</i>	67.93	6.19			
	<i>Prunus serotina</i>	12.35	0.90			
	<i>Quercus rubra</i>	18.53	1.41			
	<i>Sassafras albidum</i>	6.18	0.19			
	<i>Ulmus rubra</i>	30.88	1.14			
	Totals:	382.85	20.18		926.25	3.73

Table A-2. Continued

Site ID	Overstory (>12.7 cm dbh)			Midstory (2.5-12.45 cm dbh)		
	Species	Trees/ha	Basal area (m ²)/ha	Species	Trees/ha	Basal area (m ²)/ha
4C	<i>Acer rubrum</i>	12.35	0.52	<i>Acer saccharum</i>	247.00	1.16
	<i>Acer saccharum</i>	12.35	0.56	<i>Fagus grandifolia</i>	123.50	1.07
	<i>Fagus grandifolia</i>	12.35	1.72	<i>Liriodendron tulipifera</i>	679.25	4.01
	<i>Liriodendron tulipifera</i>	222.30	15.39			
	<i>Quercus alba</i>	6.18	0.48			
	<i>Quercus rubra</i>	6.18	0.17			
	<i>Robinia pseudoacacia</i>	43.23	1.40			
	Totals:	314.93	20.24		1049.75	6.24
4D	<i>Acer rubrum</i>	6.18	0.63	<i>Acer saccharum</i>	61.75	0.32
	<i>Acer saccharum</i>	55.58	1.72	<i>Fagus grandifolia</i>	123.50	0.85
	<i>Fagus grandifolia</i>	30.88	2.91	<i>Liriodendron tulipifera</i>	185.25	0.81
	<i>Liriodendron tulipifera</i>	104.98	4.19	<i>Robinia pseudoacacia</i>	308.75	2.21
	<i>Quercus velutina</i>	6.18	0.51			
	<i>Robinia pseudoacacia</i>	43.23	1.84			
	Totals:	247.00	11.80		679.25	4.19

Table A-2. Continued

Site ID	Overstory (>12.7 cm dbh)			Midstory (2.5-12.45 cm dbh)		
	Species	Trees/ha	Basal area (m ²)/ha	Species	Trees/ha	Basal area (m ²)/ha
5A	<i>Acer rubrum</i>	86.45	3.08	<i>Acer rubrum</i>	61.75	0.43
	<i>Acer saccharum</i>	104.98	3.72	<i>Acer saccharum</i>	802.75	2.67
	<i>Betula lenta</i>	55.58	2.22	<i>Betula lenta</i>	61.75	0.36
	<i>Carya spp.</i>	12.35	0.23	<i>Carya spp.</i>	61.75	0.30
	<i>Fagus grandifolia</i>	74.10	4.24	<i>Fagus grandifolia</i>	123.50	0.45
	<i>Fraxinus americana</i>	12.35	0.46			
	<i>Liriodendron tulipifera</i>	49.40	3.06			
	<i>Prunus pennsylvanica</i>	12.35	0.95			
	<i>Prunus serotina</i>	24.70	3.05			
	<i>Quercus prinus</i>	6.18	0.15			
	<i>Quercus rubra</i>	6.18	0.67			
	<i>Tilia americana</i>	6.18	0.97			
	<i>Ulmus rubra</i>	6.18	0.26			
	Totals:	456.95	23.05		1111.50	4.21
5C	<i>Acer rubrum</i>	61.75	3.36	<i>Acer rubrum</i>	432.25	1.86
	<i>Fagus grandifolia</i>	18.53	1.04	<i>Acer saccharum</i>	61.75	0.23
	<i>Liriodendron tulipifera</i>	92.63	6.60	<i>Fagus grandifolia</i>	308.75	0.97
	<i>Magnolia fraseri</i>	6.18	0.14	<i>Liriodendron tulipifera</i>	61.75	0.21
	<i>Nyssa sylvatica</i>	55.58	1.91	<i>Magnolia fraseri</i>	123.50	0.63
	<i>Quercus prinus</i>	111.15	10.09			
	<i>Quercus rubra</i>	18.53	1.60			
	<i>Robinia pseudoacacia</i>	12.35	0.49			
	Totals:	376.68	25.23		988.00	3.90

Table A-3. Landing size and soil test results before reclamation of log landings using native and traditional seed mixtures in the Upper Elk Watershed, West Virginia, 2005–2006.

Year	Seed mixture	Size (ha)	pH^a	Available phosphorus (P) (kg/ha)^b	Available potassium (K) (kg/ha)^c
2005	Erosion control	0.16-0.28	5.8-6.4	18-108	209-220
	Wildlife	0.20-0.25	5.4-6.8	92-109	216-226
	Wildflower	0.20-0.22	6.6-7.1	149-174	202-219
	Traditional	0.14-0.18	6.0-6.7	67-116	197-213
2006	Erosion control	0.12-0.28	6.2-6.7	87-162	195-208
	Wildlife	0.12-0.28	6.6-7.0	154-182	209-217
	Wildflower	0.16-0.22	6.5-6.8	129-188	192-212
	Traditional	0.14-0.20	6.7-6.9	107-148	177-200

^a0.38-0.72 kg/ha lime was recommended for landings with pH < 6.0

^b140 kg/ha nitrogen was recommended for all landings along with 90 kg/ha phosphate on landings with available phosphorus < 20 kg/ha.

^cNo recommendations were made for potassium as it was high on all landings.

Table A-4. Analysis of variance model used to examine differences among seed mixtures in vegetation biomass, percent cover, height, and forage quality on log landings during July and September in the Upper Elk Watershed, West Virginia, 2005–2006.

Effect	<i>df</i>	Variable description
Mixture	3	Seed mixture
Block	3	Replication of each seed mixture
Month (year)	2	Month of data collection within year
Year	1	Year of data collection
Excl PP (mixture)	4	Exclosure vs. paired plot comparison within seed mixtures

Table A-5. Analysis of variance model used to examine differences among seed mixtures in small mammal relative abundance and species richness on log landings during June-October in the Upper Elk Watershed, West Virginia, 2005–2006.

Source	<i>df</i>	Variable description
Mixture	3	Seed mixture
Block	3	Replication of each seed mixture
Month (year)	4	Month of data collection within year
Year	1	Year of data collection
Transect (mixture)	4	Center and edge transects within seed mixtures

Table A-6. Precipitation, percent slope, and sediments (kg/m²) collected June–October in 2005 from planted log landings in the Upper Elk Watershed, West Virginia.

2005	Rainfall (mm)	Erosion control		Wildlife		Wildflower		Traditional	
		Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
June	32.18	0.68	0.18	0.00	0.63	0.32	- ^a	0.00	-
July	90.98	0.60	0.68	0.00	1.18	0.12	-	0.00	-
August	52.18	1.74	0.70	0.00	2.47	0.22	-	0.00	-
September	53.79	0.22	0.22	0.05	0.56	0.13	-	0.00	-
October	70.56	<u>0.15</u>	<u>0.05</u>	<u>0.08</u>	<u>0.10</u>	<u>0.08</u>	<u>-</u>	<u>0.00</u>	<u>-</u>
	Total Sediments:	3.39	1.83	0.13	5.40	0.87	-	0.00	-
	% Slope:	3.00	1.60	8.20	2.60	4.20	0.25	4.10	0.40

^a Sites with missing values were not collected for sediment due to < 1% slope.

Table A-7. Species composition of clipped vegetation on log landings planted with reclamation seed mixtures in the Upper Elk Watershed located in West Virginia before planting, 2 months (July) after growth, and 4 months (September) after growth. Only 4 of 20 clipped landings were sampled in both years.

Mixture	Species	% Composition (pre-planting)	2005 % Composition		2006 % Composition			
			July	September	July	September		
Erosion control	<i>Triticum aestivum L.</i>	40	n = 2	15	3	n = 3	8	3
	<i>Festuca rubra</i>	30		45	45		50	53
	<i>Elymus villosus</i>	24		23	25		15	10
	<i>Panicum clandestinum, Tioga</i>	6		5	13		20	24
	Other	0		13	15		8	10
Wildlife	<i>Trifolium repens, Ladino</i>	49	n = 2	25	30	n = 3	30	40
	<i>Chamaecrista fasciculata</i>	25		33	38		40	30
	<i>Festuca rubra</i>	14		20	13		8	5
	<i>Triticum aestivum L.</i>	10		13	3		5	0
	<i>Panicum clandestinum, Tioga</i>	2		5	8		8	10
	<i>Rubus allegheniensis</i>	1		0	5		5	10
	Other	0		5	5		5	5
Wildflower	<i>Rudbeckia hirta</i>	21	n = 2	45	38	n = 3	45	58
	<i>Triticum aestivum</i>	20		0	0		5	0
	<i>Festuca rubra</i>	15		5	5		8	5
	<i>Elymus villosus</i>	12		0	5		0	0
	<i>Desmodium canadense</i>	10		0	3		0	0
	<i>Lupinus perennis</i>	10		5	8		8	5
	<i>Heliopsis helianthoides</i>	5		35	28		13	24
	<i>Aster novae-anglicae</i>	4		5	0		5	0
	<i>Panicum clandestinum, Tioga</i>	3		3	5		3	3
	Other	0		3	13		8	5
Traditional	<i>Dactylis glomerata L.</i>	20	n = 2	25	25	n = 3	30	25
	<i>Lolium perenne L.</i>	20		15	8		8	10
	<i>Secale cereale</i>	20		8	3		8	0
	<i>Phleum pretense</i>	20		20	20		18	15
	<i>Trifolium pretense</i>	16		13	20		15	25
	<i>Lotus corniculatus</i>	14		10	15		13	15
	Other	10		10	10		8	10

Table A-8. Small mammals captured on log landings reclaimed with traditional and native seed mixtures in the Upper Elk Watershed, West Virginia, 2005 – 2006.

Year	Month	Site*	Species	# Captured
2005	June	1A	<i>Clethrionomys gapperi</i>	1
			<i>Peromyscus leucopus</i>	14
			<i>Peromyscus maniculatus</i>	6
			<i>Tamias striatus</i>	2
		1B	<i>Microtus pinetorum</i>	2
			<i>Peromyscus leucopus</i>	3
			<i>Peromyscus maniculatus</i>	3
		1C	<i>Napaeozapus insignis</i>	1
			<i>Peromyscus leucopus</i>	4
		1D	<i>Peromyscus leucopus</i>	6
			<i>Peromyscus maniculatus</i>	1
			<i>Tamias striatus</i>	1
		2A	<i>Clethrionomys gapperi</i>	2
			<i>Peromyscus leucopus</i>	2
			<i>Peromyscus maniculatus</i>	1
		2B	<i>Peromyscus leucopus</i>	5
		2C	-	-
		2D	<i>Peromyscus leucopus</i>	3
			<i>Peromyscus maniculatus</i>	1
	August	1A	<i>Blarina brevicauda</i>	1
			<i>Microtus pennsylvanicum</i>	1
			<i>Peromyscus leucopus</i>	15
			<i>Peromyscus maniculatus</i>	2
			<i>Tamias striatus</i>	4
		1B	<i>Peromyscus leucopus</i>	7
		1C	<i>Blarina brevicauda</i>	1
			<i>Peromyscus leucopus</i>	4
			<i>Peromyscus maniculatus</i>	3
		1D	<i>Peromyscus leucopus</i>	8
			<i>Peromyscus maniculatus</i>	1
			<i>Tamias striatus</i>	2
		2A	<i>Peromyscus leucopus</i>	5
			<i>Sorex fumeus</i>	1
		2B	<i>Blarina brevicauda</i>	2
			<i>Peromyscus leucopus</i>	5
			<i>Sorex cinereus</i>	1
			<i>Sorex fumeus</i>	1
		2C	<i>Napaeozapus insignis</i>	1
			<i>Peromyscus leucopus</i>	8
			<i>Sorex fumeus</i>	2
		2D	<i>Peromyscus leucopus</i>	4
			<i>Peromyscus maniculatus</i>	1

Table A-8. Continued

Year	Month	Site*	Species	# Captured
	October	1A	<i>Clethrionomys gapperi</i>	3
			<i>Peromyscus leucopus</i>	12
			<i>Peromyscus maniculatus</i>	3
			<i>Sorex fumeus</i>	4
		1B	<i>Neotoma magister</i>	1
			<i>Peromyscus leucopus</i>	12
			<i>Peromyscus maniculatus</i>	3
			<i>Sorex fumeus</i>	1
		1C	<i>Clethrionomys gapperi</i>	2
			<i>Microtus pinetorum</i>	1
			<i>Peromyscus leucopus</i>	6
			<i>Peromyscus maniculatus</i>	3
			<i>Sorex fumeus</i>	7
			<i>Tamias striatus</i>	1
		1D	<i>Clethrionomys gapperi</i>	1
			<i>Neotoma magister</i>	1
			<i>Peromyscus leucopus</i>	13
			<i>Sorex fumeus</i>	3
		2A	<i>Peromyscus leucopus</i>	6
			<i>Peromyscus maniculatus</i>	1
			<i>Sorex fumeus</i>	2
			<i>Tamias striatus</i>	1
		2B	<i>Peromyscus leucopus</i>	5
			<i>Sorex fumeus</i>	2
		2C	<i>Peromyscus leucopus</i>	3
			<i>Peromyscus maniculatus</i>	8
			<i>Sorex fumeus</i>	3
		2D	<i>Peromyscus leucopus</i>	3
			<i>Peromyscus maniculatus</i>	1
2006	June	1A	<i>Clethrionomys gapperi</i>	5
			<i>Microtus pinetorum</i>	1
			<i>Peromyscus leucopus</i>	4
			<i>Peromyscus maniculatus</i>	2
			<i>Tamias striatus</i>	4
		1B	<i>Blarina brevicauda</i>	1
			<i>Clethrionomys gapperi</i>	2
			<i>Neotoma magister</i>	2
			<i>Peromyscus leucopus</i>	5
			<i>Peromyscus maniculatus</i>	2
			<i>Tamias striatus</i>	2

Table A-8. Continued

Year	Month	Site*	Species	# Captured
		1C	<i>Clethrionomys gapperi</i>	2
			<i>Napaeozapus insignis</i>	1
			<i>Peromyscus leucopus</i>	5
			<i>Peromyscus maniculatus</i>	2
			<i>Tamias striatus</i>	1
		1D	<i>Peromyscus leucopus</i>	1
			<i>Peromyscus maniculatus</i>	2
			<i>Tamias striatus</i>	3
		2B	<i>Blarina brevicauda</i>	1
			<i>Peromyscus leucopus</i>	6
			<i>Peromyscus maniculatus</i>	1
			<i>Tamias striatus</i>	3
		3A	<i>Clethrionomys gapperi</i>	2
			<i>Peromyscus leucopus</i>	2
			<i>Peromyscus maniculatus</i>	1
		3B	<i>Clethrionomys gapperi</i>	2
			<i>Napaeozapus insignis</i>	3
			<i>Peromyscus leucopus</i>	8
			<i>Peromyscus maniculatus</i>	2
		3D	<i>Peromyscus leucopus</i>	2
			<i>Peromyscus maniculatus</i>	2
		4C	<i>Blarina brevicauda</i>	1
			<i>Peromyscus leucopus</i>	2
		4D	<i>Peromyscus leucopus</i>	1
		5A	<i>Peromyscus maniculatus</i>	4
		5C	<i>Peromyscus leucopus</i>	2
			<i>Peromyscus maniculatus</i>	3
	August	1A	<i>Clethrionomys gapperi</i>	1
			<i>Microtus pinetorum</i>	1
			<i>Peromyscus leucopus</i>	4
			<i>Peromyscus maniculatus</i>	2
			<i>Tamias striatus</i>	1
		1B	<i>Clethrionomys gapperi</i>	1
			<i>Microtus pinetorum</i>	1
			<i>Neotoma magister</i>	2
			<i>Peromyscus leucopus</i>	2
			<i>Peromyscus maniculatus</i>	5
			<i>Tamias striatus</i>	1
		1C	<i>Napaeozapus insignis</i>	1
			<i>Peromyscus leucopus</i>	3
			<i>Peromyscus maniculatus</i>	3
			<i>Tamias striatus</i>	1

Table A-8. Continued

Year	Month	Site*	Species	# Captured
		1D	<i>Blarina brevicauda</i>	2
			<i>Peromyscus leucopus</i>	4
			<i>Peromyscus maniculatus</i>	3
			<i>Tamias striatus</i>	2
		2B	<i>Blarina brevicauda</i>	2
			<i>Peromyscus leucopus</i>	3
			<i>Peromyscus maniculatus</i>	3
			<i>Tamias striatus</i>	1
		3A	<i>Clethrionomys gapperi</i>	4
			<i>Neotoma magister</i>	1
			<i>Peromyscus leucopus</i>	1
			<i>Peromyscus maniculatus</i>	4
		3B	<i>Clethrionomys gapperi</i>	3
			<i>Microtus pinetorum</i>	1
			<i>Napaeozapus insignis</i>	3
			<i>Peromyscus leucopus</i>	10
			<i>Peromyscus maniculatus</i>	1
		3D	<i>Peromyscus maniculatus</i>	3
		4C	<i>Peromyscus leucopus</i>	6
		4D	<i>Blarina brevicauda</i>	1
			<i>Peromyscus leucopus</i>	3
			<i>Zapus hudsonius</i>	1
		5C	<i>Clethrionomys gapperi</i>	1
			<i>Peromyscus leucopus</i>	1
			<i>Peromyscus maniculatus</i>	3
			<i>Tamias striatus</i>	1
	October	1A	<i>Blarina brevicauda</i>	2
			<i>Clethrionomys gapperi</i>	3
			<i>Microtus pinetorum</i>	1
			<i>Peromyscus leucopus</i>	6
			<i>Peromyscus maniculatus</i>	2
			<i>Tamias striatus</i>	1
		1B	**	
		1C	**	
		1D	**	
		2B	**	
		3A	**	
		3B	<i>Blarina brevicauda</i>	1
			<i>Peromyscus leucopus</i>	4
			<i>Peromyscus maniculatus</i>	3
			<i>Sorex cinereus</i>	1

Table A-8. Continued

Year	Month	Site*	Species	# Captured
		3D	**	
		4C	<i>Blarina brevicauda</i>	4
			<i>Peromyscus leucopus</i>	3
			<i>Peromyscus maniculatus</i>	3
		4D	<i>Blarina brevicauda</i>	6
			<i>Clethrionomys gapperi</i>	1
			<i>Microtus pinetorum</i>	1
			<i>Peromyscus leucopus</i>	1
			<i>Peromyscus maniculatus</i>	1
		5A	**	
		5C	**	

*A = erosion mixture; B = traditional mixture; C = wildlife mixture; D = wildflower mixture

**No data collected for this trapping month

Table A-9. Compromise programming metric values for individual criteria with p = 1, 2, and 10 and different land manager objectives for seed mixtures planted on log landings in the Upper Elk Watershed, West Virginia. Data were standardized before analysis.

		Criteria										
Objective	Seed mixture	Small mammal relative abundance	Small mammal species richness	Vegetation height	Vegetation % cover	Vegetation biomass	Vegetation % crude protein	% Sediment reduction	Cost	% Showy flowers	Native vs. non-native	Total
Unweighted												
p = 1	Erosion control	0.00	0.07	0.05	0.10	0.05	0.10	0.07	0.00	0.10	0.00	0.55
	Wildlife	0.10	0.06	0.09	0.06	0.09	0.01	0.02	0.03	0.03	0.00	0.49
	Wildflower	0.09	0.10	0.10	0.10	0.10	0.09	0.10	0.10	0.00	0.00	0.78
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.10	0.17
p = 2	Erosion control	0.00	0.05	0.02	0.10	0.02	0.10	0.05	0.00	0.10	0.00	0.67
	Wildlife	0.10	0.03	0.08	0.04	0.08	0.00	0.00	0.01	0.01	0.00	0.60
	Wildflower	0.08	0.10	0.10	0.10	0.10	0.09	0.10	0.10	0.00	0.00	0.88
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.10	0.38
p = 10	Erosion control	0.00	0.00	0.00	0.09	0.00	0.10	0.00	0.00	0.10	0.00	0.88
	Wildlife	0.10	0.00	0.04	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.84
	Wildflower	0.03	0.10	0.10	0.10	0.10	0.06	0.10	0.10	0.00	0.00	0.96
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.80
Landowner (hunter)												
p = 1	Erosion control	0.00	0.00	0.05	0.10	0.05	0.20	0.05	0.00	0.09	0.00	0.54
	Wildlife	0.10	0.00	0.09	0.06	0.09	0.02	0.01	0.03	0.03	0.00	0.44
	Wildflower	0.09	0.00	0.10	0.10	0.10	0.19	0.07	0.10	0.00	0.00	0.74
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.15	0.21
p = 2	Erosion control	0.00	0.00	0.02	0.10	0.02	0.20	0.03	0.00	0.09	0.00	0.68
	Wildlife	0.10	0.00	0.08	0.04	0.08	0.00	0.00	0.01	0.01	0.00	0.57
	Wildflower	0.08	0.00	0.10	0.10	0.10	0.18	0.07	0.10	0.00	0.00	0.85
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.15	0.44
p = 10	Erosion control	0.00	0.00	0.00	0.09	0.00	0.20	0.00	0.00	0.09	0.00	0.91
	Wildlife	0.10	0.00	0.04	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.84
	Wildflower	0.03	0.00	0.10	0.10	0.10	0.12	0.07	0.10	0.00	0.00	0.95
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.83

Table A-9. Continued

		Criteria										
Objective	Seed mixture	Small mammal relative abundance	Small mammal species richness	Vegetation height	Vegetation % cover	Vegetation biomass	Vegetation % crude protein	% Sediment reduction	Cost	% Showy flowers	Native vs. non-native	Total
Landowner (aesthetic)												
p = 1	Erosion control	0.00	0.00	0.07	0.25	0.00	0.00	0.07	0.00	0.30	0.00	0.70
	Wildlife	0.00	0.00	0.14	0.16	0.00	0.00	0.02	0.03	0.10	0.00	0.44
	Wildflower	0.00	0.00	0.15	0.25	0.00	0.00	0.10	0.10	0.00	0.00	0.60
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.10	0.30
p = 2	Erosion control	0.00	0.00	0.03	0.24	0.00	0.00	0.05	0.00	0.30	0.00	0.79
	Wildlife	0.00	0.00	0.12	0.10	0.00	0.00	0.00	0.01	0.03	0.00	0.52
	Wildflower	0.00	0.00	0.15	0.25	0.00	0.00	0.10	0.10	0.00	0.00	0.77
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.10	0.48
p = 10	Erosion control	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.30	0.00	0.94
	Wildlife	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76
	Wildflower	0.00	0.00	0.15	0.25	0.00	0.00	0.10	0.10	0.00	0.00	0.95
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.10	0.80
Timber company												
p = 1	Erosion control	0.00	0.00	0.00	0.30	0.00	0.00	0.22	0.02	0.00	0.00	0.53
	Wildlife	0.00	0.00	0.00	0.19	0.00	0.00	0.05	0.13	0.00	0.00	0.37
	Wildflower	0.00	0.00	0.00	0.30	0.00	0.00	0.30	0.40	0.00	0.00	1.00
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
p = 2	Erosion control	0.00	0.00	0.00	0.29	0.00	0.00	0.16	0.00	0.00	0.00	0.67
	Wildlife	0.00	0.00	0.00	0.12	0.00	0.00	0.01	0.04	0.00	0.00	0.41
	Wildflower	0.00	0.00	0.00	0.30	0.00	0.00	0.30	0.40	0.00	0.00	1.00
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
p = 10	Erosion control	0.00	0.00	0.00	0.06	0.00	0.00	0.01	0.00	0.00	0.00	0.88
	Wildlife	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.55
	Wildflower	0.00	0.00	0.00	0.30	0.00	0.00	0.30	0.40	0.00	0.00	1.00
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A-9. Continued

		Criteria										
Objective	Seed mixture	Small mammal relative abundance	Small mammal species richness	Vegetation height	Vegetation % cover	Vegetation biomass	Vegetation % crude protein	% Sediment reduction	Cost	% Showy flowers	Native vs. non- native	Total
Wildlife manager												
p = 1	Erosion control	0.01	0.09	0.03	0.07	0.04	0.15	0.05	0.00	0.08	0.00	0.51
	Wildlife	0.13	0.07	0.05	0.04	0.07	0.02	0.01	0.03	0.03	0.00	0.45
	Wildflower	0.11	0.13	0.06	0.07	0.08	0.14	0.07	0.10	0.00	0.00	0.75
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.15	0.20
p = 2	Erosion control	0.00	0.06	0.01	0.07	0.02	0.15	0.03	0.00	0.08	0.00	0.65
	Wildlife	0.13	0.04	0.05	0.03	0.06	0.00	0.00	0.01	0.01	0.00	0.57
	Wildflower	0.10	0.13	0.06	0.07	0.08	0.13	0.07	0.10	0.00	0.00	0.86
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.15	0.43
p = 10	Erosion control	0.00	0.00	0.00	0.06	0.00	0.15	0.00	0.00	0.08	0.00	0.88
	Wildlife	0.13	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.84
	Wildflower	0.04	0.13	0.06	0.07	0.08	0.09	0.07	0.10	0.00	0.00	0.95
	Traditional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.83

Figure A-1. 1992 Logging Sediment Control Act of West Virginia (revised 1998)

Figure A-2. 2005 West Virginia Logging Best Management Practices Manual

W. VA. LOGGING SEDIMENT CONTROL ACT

INTRODUCTION

In 1992, the West Virginia Legislature enacted the Logging Sediment Control Act. The purpose of the act is to protect and maintain forest water and site productivity by minimizing soil erosion from areas disturbed during timber harvesting operations. Provisions of this act include:

Logger Licensing

Logger Certification

Notification

Job Posting

Enforcement

The West Virginia Division of Forestry was designated by the Legislature as the agency responsible for carrying out the mandates and provisions of the Logging Sediment Control Act.

LOGGER LICENSING

After September 1, 1992, anyone **conducting a logging operation, buying standing timber, or buying logs for resale** is required to be licensed by the West Virginia Division of Forestry. The annual fee is \$50 and includes any one, or any combination of, the three categories. One requirement for licensing is that the person or company be registered by the West Virginia Department of Tax and Revenue; the registration number must be supplied with the application for licensing. Acceptance of the license implies that the logging operator will protect environmental quality through the judicious use of Best Management Practices.

LOGGER CERTIFICATION

The second main provision of the law provides for the certification of loggers. The fee for certification is also \$50 annually. The requirements for certification are the satisfactory completion of courses in tree felling safety and personal safety equipment, first aid, and Best Management Practices.

After July 1, 1993, each logging crew is required to be supervised by a certified logger, who must be on the job each day but does not have to be continuously present. The certification can be renewed for two successive years, but certified loggers must attend an update training course, approved by the Director of the Division of Forestry, before being recertified for the third year.

NOTIFICATION AND JOB POSTING

A third provision requires logging operators to submit a notification form to the Division of Forestry within three days of starting a new harvesting operation. Along with notification, the operator is required to post the logging job with a sign indicating the company name and license number. The posted sign must be plainly visible on a log landing of an active operation.

ENFORCEMENT

The law also specifies several ways in which licenses can be suspended and/or revoked. These provisions have been amplified by the writing of regulations by the Division of Forestry and approved by the Legislative Rule-Making Review Committee.

The law, and accompanying regulations, empowers the Division of Forestry to issue compliance orders to correct problems and, when necessary, to suspend a logging operation until specified corrections are made to bring the operation into compliance with the law. The operation may be immediately suspended when human life is endangered, uncorrectable damage to the environment is imminent, an operator is not licensed, uncorrectable water pollution may result, or a certified logger is not supervising the operation. Licenses may be suspended if the person is found in violation twice in any two-year period, and they may be revoked if found guilty for a third time in any two-year period.

If a logging operator feels that the Division of Forestry has acted improperly, an appeal of the Division of Forestry's ruling may be filed with an informal conference panel composed of three persons. Establishment of these informal conference panels is provided by the legislation.

The Director of the Division of Forestry also may seek civil penalties for violations of the law in the Circuit Court of the county in which the violation occurred, in an amount not to exceed \$2,500 for the first offense and \$5,000 for any subsequent offense. However, the inspector generally will give the logging operator a specified number of days to correct the situation.

All penalties collected are deposited in a Timbering Operations and Enforcement Fund for use in administering the law.

The law also provides that all state agencies will cooperate with the Director in administering the law, and that the Director will cooperate with all other state agencies in the enforcement of their responsibilities and duties.

The law provides exceptions for utilities and right-of-way clearing, ground disturbing construction, Christmas tree severing, companies regulated by the Federal Energy Regulatory Commission, and people harvesting timber and other wood products on their own property for their own use. An application can be submitted for a waiver from licensing and certification for occasionally severing or removing standing trees for sale, either from the harvester's property or from the property of another, provided the aggregate gross income realized from all sales of the forest products within any calendar year does not exceed \$15,528. However, a notification form still must be submitted to the Division of Forestry.

It should be noted that landowners have a responsibility to prevent sedimentation of the state's streams. Under Chapter 22 of the Code of West Virginia and enforced by the Office of Water Resources of the West Virginia Division of Environmental Protection, landowners can be held legally responsible for allowing or contributing to stream sedimentation or even stream turbidity due to logging.

West Virginia Silvicultural
BEST MANAGEMENT PRACTICES
for Controlling Soil Erosion and Sedimentation
from Logging Operations

Revised 1989, 1995, 1996, 2001, 2002, 2005

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INTRODUCTION

It should be noted that the silvicultural Best Management Practices recommended in this booklet are not the only acceptable ones. Situations will arise that require custom or alternative practices to be used to get the job done and minimize any erosion hazard as mandated by the Logging Sediment Control Act. However, the law does require that Best Management Practices, West Virginia Code 19-1B-7(g), be used for controlling erosion and soil movement into streams.

Excess soil sediment has been described as the greatest single contaminant by volume of lakes, streams and rivers. Sediment containing organic matter can create a biochemical oxygen demand in natural waters that damages the habitat of fish and other aquatic life, reduce recreational values, and adversely affect water supplies. It can also clog stream channels, contributing to increased stream bank and channel erosion. Eroded soil particles may carry pesticides, herbicides, fertilizers and other chemicals.

It is a proven fact that cutting trees does not cause erosion. However, improperly performed logging operations and related activities (especially improperly planned and constructed roads and landings), along with certain silviculture activities that expose mineral soil (such as site preparation, mechanical tree planting, etc.), are contributing factors causing soil loss and sedimentation.

Reclamation, whether temporary or permanent, must be progressive during the logging operation to prevent and control soil erosion and sedimentation. This will maximize soil and water protection while providing operating efficiency for the logger.

Through positive efforts of people involved in the sediment control program, the objective of keeping sediment out of State waters will be met.

LOGGING SEDIMENT CONTROL ACT SUMMARY

1. Logger Licensing
2. Logger Certification
3. Timbering Operation Notification
4. Logging Operation Posting
5. Enforcement for activities causing erosion and/or stream sedimentation or the potential thereof.
6. Reclamation to be completed within 7 days of the planned completion date on the notification form. If it can't be done within 7 days, the Division of Forestry must be contacted. (See Page 26.)

The West Virginia Division of Forestry was designated by the Legislature as the agency responsible to carry out the mandates and provisions of the Logging Sediment Control Act.

The law states that after September 1, 1992, anyone conducting a logging operation, buying timber or buying logs for resale is required to be licensed by the Division of Forestry. The annual fee is \$50. The fee covers any one or any combination of the three categories stated above. Any individual or business entity applying for a license must be registered and in compliance with the West Virginia Department of Tax and Revenue and Workers' Compensation and Unemployment Compensation laws. Acceptance of the license implies that the operator will protect environmental quality through the judicious use of silvicultural Best Management Practices.

The second main provision of the law provides for the certification of loggers. The fee for certification is also \$50 annually. The requirements for certification are the satisfactory completion of courses in tree felling safety and personal safety equipment, first aid and silvicultural Best Management Practices. An initial logger certification or recertification can be renewed for two successive years, provided the logger's training is less than three years old. Retraining is required every three years.

Each logging crew is required to be supervised by a certified logger any time the timbering operation is being conducted. The certified logger must be physically present to observe and supervise the work and performance of logging crew personnel while engaged

in logging activities, including the severing and delimbing of trees, the cutting of delimbed trees into logs, the preparation of any skid and haul roads and installation of BMP's and administering first aid procedures.

A third provision was for loggers to submit a timbering operation notification form within three days of starting a new harvesting operation. Along with notification, the timber operator is required to post the operation with a sign listing the timber operator's name and license number in letters that are at least 3" high. The posted sign must remain on each active log landing of the operation.

The law also specifies several ways in which licenses can be suspended and/or revoked. These provisions have been amplified by the writing of regulations available from the Division of Forestry.

The law empowers the Division of Forestry to issue compliance orders to correct problems and, when necessary, to suspend a logging operation until specified corrections are made to bring the operator or operation into compliance with the law. Instances include when human life is endangered, uncorrectable damage to the environment is imminent, an operation is not licensed, uncorrectable water pollution may result, or when a certified logger is not supervising the operation. Licenses may be suspended if the person is found to be in violation twice in any two-year period, and they may be revoked if the logger is found in violation for a third time in any two-year period.

If a logger feels that the Division of Forestry has acted improperly, the logger must appeal within 48 hours to the Division of Forestry. A conference panel, composed of three persons, will be brought together for an informal ruling.

The Director of the Division of Forestry (hereinafter referred to as Director) may also seek civil penalties for violations of the law in the Circuit Court of the county in which the violation occurred, in an amount not to exceed \$2,500 for the first offense and \$5,000 for any subsequent offense. For less serious violations, the Director will generally give the logging operator a specified number of days to correct the situation.

All penalties collected are deposited in a Timbering Operations and Enforcement Fund for use in administering the law.

The Division of Forestry may also issue citations to any person who knowingly or willingly commits one of the following

violations and if found guilty in magistrate court, shall be fined not less than \$250 and not more than \$500 for each violation:

(1) Conducts timbering operations or purchases timber or buys logs for resale in this State without holding a valid license from the Director of the Division of Forestry;

(2) Conducts timbering operations or severs trees for sale at a location in this State without providing the Director of the Division of Forestry with notice of the location where the timbering or harvesting operations are to be conducted;

(3) Conducts a timbering operation in this State that is not supervised by a certified logger who holds a valid certificate from the Division of Forestry; or

(4) Continues to conduct timbering or logging operations in violation of an existing suspension or revocation order that has been issued by the Director of the Division of Forestry or a conference panel.

The law also provides that all State agencies shall cooperate with the Director in administering the law and that the Director shall cooperate with all other State agencies in the enforcement of their responsibilities and duties.

There are exceptions provided for in the law for utilities and right-of-way clearing, ground-disturbing construction, Christmas tree severing, companies regulated by the federal energy regulatory commission and for people harvesting on their own property for their own use, provided that the individual does not have the severing done by a person whose business is the severing or removal of trees. An exemption from licensing and certification can be obtained by a landowner or contractor who is severing or removing standing trees for sale, on his or her own property or property of another, if the aggregate gross stumpage value for all sales within any calendar year does not exceed \$15,528. The exemption must be approved by the Division of Forestry, and a Harvesting of Timber Notification form must be submitted.

To apply for a timber-harvesting exemption, contact one of the six Division of Forestry offices listed on Page 26.

It should be noted that landowners also have a responsibility in preventing sedimentation of the State's streams. Under Chapter 22 of the Code of West Virginia and enforced by the Division of Water Resources of the State Department of Environmental Protection, landowners can be held legally responsible for allowing or contributing to stream sedimentation or even stream turbidity due to logging.

STREAM DEFINITIONS

Perennial stream--Identified by well defined banks and natural channels and have continuously flowing water most years. They are usually shown on a topographic map (USGS 7.5 minute series) as a solid blue line.

Intermittent stream--Has well defined banks and natural channels, but typically has flowing water from a headwater source for only a portion of the year. They are usually shown on a topographic map (USGS 7.5 minute series) as broken blue lines.

Ephemeral stream--A channel that flows as a result of wet weather conditions when the ground is saturated. Not shown on topographic maps (USGS 7.5 minute series).

STREAMSIDE MANAGEMENT ZONES AND SHADE STRIP AREAS

Definitions

Streamside management zone. Vegetated land adjacent to perennial, intermittent and ephemeral streams and ponds or lakes requiring special attention during forestry operations. These are sensitive areas where nonpoint source pollutants can enter the aquatic system. An area of undisturbed forest soil between areas disturbed to mineral soil and a stream bank, it provides a protective zone to trap and filter out suspended sediments before these particulates reach the stream. Any forestry operations should establish or enhance the riparian area while meeting the landowner's objectives.

Shade Strip (buffer strip). A no-cut or light-cut area that provides adequate shading of perennial or intermittent streams so as to stabilize and preserve the biological value of the stream.

Conditions Where Streamside Management Zones Apply

Streamside management zones should be maintained among all streams, watercourses, truck haul roads, skid roads and landings where soil has been exposed and surface runoff will carry sediment loads. Streamside management zones should be at least 100' wide on each side of perennial or intermittent streams and 25' wide on each side of ephemeral streams. Adequate streamside management zones should be maintained around all lakes or ponds, perennial flowing natural springs, and all springs and reservoirs serving as a domestic water supply.

Streamside Management Zones (SMZ)

Stream	Stream	SMZ's	Log Haul
Bed	Bank		Road

On perennial and intermittent streams, 100' wide; on ephemeral stream flows, 25' wide.

Streamside Management Zone Requirements

1. The minimum streamside management zone width or distance between roads or landings (exposed mineral soil) and a perennial or intermittent stream should be 100 feet slope distance on each side from the top of the channel. On ephemeral streams, it should be 25 feet on each side from the top of the channel.
2. The streamside management zone should be protected to prevent exposure of mineral soil and subsequent erosion. Equipment operation in this area should be limited. However, cutting and pulling trees from the area is permitted. If mineral soil is exposed, it will be stabilized by seeding and mulching as soon as possible.
3. Log landings will be located outside the streamside management zone where practical. If circumstances or specific reasons prevent this, then the landing will be treated as a sensitive area, and additional protective measures such as sediment barriers, wooden mats and/or gravel should be used.
4. Log landing fill areas within the streamside management zone will be seeded and mulched immediately after construction.
5. Truck roads and skid roads should not be within the streamside management zone except when entering and leaving stream crossings.
6. Truck haul roads built, under certain circumstances and for specific reasons, within a streamside management zone should be graveled and fill slopes seeded and mulched immediately after construction.
7. Existing roads within the streamside management zone can be utilized only if using them will cause less damage than constructing a new road. Existing roads will be maintained in accordance with all requirements of haul and skid roads that reduce soil erosion and sedimentation.
8. Recommended spacing of drainage structures such as culverts, water bars, turn-outs and broad-based dips should be used on truck and skid roads to intercept and properly discharge runoff in small quantities so the filter capacity within the streamside management zone will not be exceeded.
9. Rip-rap erosion control will be installed at culvert outlets or discharge points into or within the streamside management zone. (See Page 21)
10. To minimize erosion sources, cut and fill slopes within the streamside management zone should be minimized in accordance with safety and other design criteria.
11. Skid road fill slopes within the streamside management zone will be seeded and mulched immediately after construction.
12. Sediment barriers, such as silt fence and/or hay or straw bales, shall be used between streams and disturbed areas (roads and landings) to prevent sediment from entering streams.
13. Wooden mats can be used on roads and landings to control rutting; these mats should be in place before trucking begins.

LOGGING DEBRIS AND TREE TOPS IN STREAMS

Directional felling should be used to minimize stream disturbance. Felled tops in streams will be pulled from the stream channel on all perennial and intermittent streams. Small logging debris can be harmful to the stream channel causing bank erosion and channel blockage. It is also recognized that large woody vegetation in the riparian areas and stream channels can be beneficial to aquatic life.

TRUCK HAUL ROADS

Definition--A road system, temporary or permanent, utilized for transportation of wood products from the harvest site by truck.

Purpose--To provide for an efficient, safe transportation system to effectively protect the forest land and water quality when removing forest products from the harvest site, developing the forest for recreation, wildfire control, or other forest management activities.

Conditions Where Practice Applies

When a road system is necessary to provide vehicular access for the purpose of harvesting and removing forest products.

Specifications

1. Final center line grade of road should be 10% or less. Final center line gradients not exceeding 15% are permissible for distances up to 200 feet. By breaking or changing grade frequently, less erosion problems will be encountered than on long, straight continuous gradients. There should be a minimum road surface width of 12' on the cut surface (not fill).
2. Streams should be crossed as close to a right angle to the stream as possible. Bridges or culverts should be sized so as not to impede stream flow in keeping with good drainage practices. (See "Pipe Culvert" on Page 20.) Stream fords are permissible as a last resort, but only when the stream bottom is rock based and can support truck traffic. The stream is to be crossed at a right angle, and approaches to the stream should be graveled for a distance of 100 feet each side.
3. Road gradients approaching water crossings should be broken and surface water dispersed so it will not flow directly

into the stream. Roads should be located (with the exception of stream crossings) a minimum of 100 feet or more from perennial or intermittent streams and 25' from ephemeral streams. Distance is measured from the stream bank to the bottom edge of soil disturbance, in case of fills, to the toe of the fill slope. (See "Streamside Management Zone Requirements" on Page 6.) If the recommended streamside management zone cannot be maintained, then alternative practices will be used, such as placing gravel on the road surface and immediately seeding and mulching the road fill areas.

4. Roads may be out-sloped for cross drainage. On side hills where a curb, fender or berm is necessary to protect the fill slope, the road should be in-sloped with cross drainage installed from the inside toe of slope to the outside or downhill side. (See "Pipe Culvert" on Page 20 or "Broad-Based Drainage Dip" on Page 24.) Where roads are in-sloped, cross drain interception of surface water is necessary.
5. Level areas where drainage is difficult to establish and wet floodplain soils should be avoided for road location if possible.
6. Truck roads that intersect public roads should have gravel or other aggregate up to 200 feet to keep mud off the highway. (Check county Division of Highways requirements for entering public roads.)

Truck Haul Road Maintenance

1. During construction, adequate drainage of the road surface using temporary cross drains, "turn-outs" or water bars on a day-to-day basis is desired in the event of storm flows prior to road completion and installation of a permanent drainage system.
2. During the harvest operation period, roads and their attendant drainage systems should be maintained to perform to standard. This may include additional seeding and mulching of fill slopes within the streamside management zone.
3. Operations that will cause adverse erosion and sediment problems should not be carried on in times of extreme weather conditions.

Post-Harvest Operations

If roads are to be used after logging, broad-based dips, culverts and bridges should be left intact and be periodically maintained by the landowner. If not to be used, drainage structures should be removed and road surfaces restored to a natural drainage by out-sloping smoothly at 3%, leaving existing dips and establishing water bars. Stream banks will be least disturbed if bridge abutments are left intact when bridges are removed.

SKID ROADS AND TRAILS

Definition--An unsurfaced trail or road, as narrow as safety will allow, used for skidding harvested products.

Purpose--To skid logs, tree lengths or other roundwood products from the stump to a common landing or concentration area.

Conditions Where Practice Applies

This practice is used where harvesting products requires centralizing for sawing or for loading on trucks or trailers and where topography and size of operation make skidding the primary means of collecting trees, logs or other roundwood products.

Standard

Locate landings first and lay out skid road approaches with minimum grade. Major skid roads should have planned locations to reduce erosion and sedimentation, minimize damage to the residual stand and provide the most desirable method for skidding products.

1. A goal of job planning and road layout should be to develop an average skid road spacing of about 200 feet apart.
2. Gradients should be no steeper than 15%, with the exception of short, steep segments not exceeding 20%. (Grades up to 40% are acceptable if no mineral soil is exposed.)
3. DURING LOGGING, cross drainage, including turn-outs, water bars or grade breaks for dispersing surface water, should be installed at least every 100 feet and maintained daily.

4. Skid roads should be located away from streams according to the "Streamside Management Zone Requirements" on Page 6.
5. Any skid road necessitating the crossing of a stream will require a bridge or culvert of acceptable design. Logs will not be skidded through any stream.
6. Approaches to stream crossings should be as near to right angles to the stream direction as possible.
7. **UPON FINAL COMPLETION of skidding on a road, the logger should stabilize and retire the road before any other skidding occurs.** This should be done by first removing the outer berm, out-sloping and smoothing the skid road. Next establish water bars as recommended on page 17. Water bars should be installed at a near 30- to 45-degree angle downslope, with ends open to prevent water accumulation behind them. Seed and mulch according to guidelines on page 13. Scattered logging slash may supplement water bars and seeding.
8. NEVER skid in or directly through a stream.

Portable temporary bridge.

LOG LANDINGS

Definition--An area where logs are assembled. This includes landings at the end of skid and haul roads.

Standard

This practice almost always results in the disturbance of the surface. Care should be taken to locate areas properly to minimize the chance of erosion and sedimentation.

The following points should be considered in the location and use of landings:

1. Adequate streamside management zones should be left between landings and streams. (See "Streamside Management Zone Requirements" on Page 6.)
2. Landings and yards should be located on dry, firm sites and have a slight slope to allow for drainage.
3. Provide for adequate drainage on approach roads so that road drainage does not enter landing area and cause "mudholes."
4. Provide diversion ditch around uphill side of landings where seepage and lateral flow of water is a problem.
5. When servicing equipment on site, drain old oil, etc., into containers and properly dispose of in accordance with proper solid waste disposal. All empty containers should be removed and disposed of properly.
6. Seed and mulch landings immediately following completion of operations or use of the landing. (See "Reclamation Requirements" on Page 13.)
7. Landing size should be kept to a minimum.

• RECLAMATION REQUIREMENTS •

The following areas will be **seeded**:

1. Truck haul roads that:
 - Exceed 10% slope.
 - Are within the streamside management zone.
2. All skid roads and trails that:
 - Exceed 15% slope. (Lopped slash can be placed on roads to supplement seeding.)
 - Are within the streamside management zone.

The following areas will be **seeded and mulched**:

- All landings.
- All mineral soil disturbed within the streamside management zone.
- Any road that disturbs mineral soil and exceeds 20% slope.

Note: Lime and fertilizer may be required with seeding depending on soil conditions

Seeding and Mulching will be more successful if

1. For each section in the planned logging operation, all exposed mineral soil areas that are to be seeded or seeded and mulched should have the high berms removed, outsloped, surface smoothed, water barred then seeded and mulched immediately after they are no longer needed. **Don't wait!** Some areas may require lime and/or fertilizer.
2. Landing fills and road fills will be seeded and mulched immediately after construction when inside the streamside management zone. **Maintenance mulching and some additional seeding may be needed.**
3. All compacted exposed areas should have a seed bed prepared by scarifying the surface to a depth of 2" to 3".
4. All areas seeded should have the seed covered by dragging the dozer blade, brush, chain or cable.
5. Straw is the preferred mulch, the use of hay may accelerate the spread of invasive and exotic species.

• • • • RECOMMENDED SEED MIXTURE OPTIONS • • • •
(RATES PER ACRE)

Shaded Woodland Areas

- Option 1. 30 lbs. lathco flat pea; 20 lbs. perennial ryegrass
- Option 2. 30 lbs. creeping red fescue; 10 lbs. perennial ryegrass
- Option 3. 20 lbs. tall fescue (endophyte-free); 20 lbs. lathco flat pea
- Option 4. 50 lbs. winter wheat; 8 lbs. orchard grass; 10 lbs. tall fescue (endophyte-free)

Wildlife Mix on Landings

- Option 1. 8 lbs. bird's-foot trefoil; 3 lbs. redtop; 4 lbs. orchard grass
- Option 2. 8 lbs. tioga deertongue; 6 lbs. ladino clover
- Option 3. 25 lbs. physter fescue or johnstone fescue; 2 lbs. ladino clover
- Option 4. 25 lbs. physter fescue or johnstone fescue; 5 lbs. annual ryegrass; 2 lbs. orchard grass; 3 lbs. tioga deertongue; 2 lbs. bird's-foot trefoil; 4 lbs. foxtail millet
- Option 5. 50 lbs. winter wheat; 8 lbs. orchard grass; 4 lbs. ladino clover; 6 lbs. timothy

Erosion Control in Grassland or Pastures

- Option 1. 8 lbs. bird's-foot trefoil; 4 lbs. timothy
- Option 2. 1 lb. white clover; 6 lbs. Kentucky bluegrass; 2 lbs. timothy
- Option 3. 10 lbs. orchard grass; 2 lbs. ladino clover; 3 lbs. redtop
- Option 4. 50 lbs. winter wheat; 8 lbs. orchard grass; 6 lbs. timothy

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Sensitive Areas, Stream Crossings, Etc., When Heavy Grass Cover Is Needed

- Option 1. 25 lbs. tall fescue (endophyte-free); 5 lbs. ladino clover
- Option 2. 50 lbs. winter wheat; 25 lbs. tall fescue (endophyte-free)

• • • • SEEDING DATES AND RECOMMENDATIONS • • • •

1. Best - March to June; late August through September, and early October
2. Frost Seeding - February through early March. Seeding on snow is acceptable.
3. Weather Conditions Limiting - Seeding can occur, but weather could limit success. June, July, late October, November, December, and January.
4. Add annual ryegrass (8 lbs./acre) and/or winter wheat (50 lbs./acre) to seed mixtures to provide quick ground cover and soil stabilization.
5. Lime and fertilizer will ensure a continued grass cover on dry sites and areas where the subsoil is exposed.
6. All legume seeds must be inoculated before seeding.

Reclaimed log landing.

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WATER BARS ON SKID ROADS

Definition--A water control structure constructed across a skid road (30° to 45°), usually from soil, to intercept and divert water from the road surface. Permanent water bars are usually constructed at least 1 foot to 30" in depth. Temporary water bars are usually constructed at least 6 inches to 1 foot in depth.

Conditions Where Practice Applies

On any sloping road where surface water runoff may cause erosion of the exposed road.

Specifications for Permanent Water Bars

1. Proper spacing between permanent water bars can be determined from the table on the following page. Additional water bars should be installed where water sources such as seeps are intercepted by roads.
2. Installation should be at an angle of 30° to 45° downslope or more to turn surface water off the road or trail.
3. A shallow trench should be dug 1 foot below the surface of the road or trail and extend beyond both sides.
4. Fill dirt from the dug water bar should be left intact.
5. The uphill end of the water bar should extend beyond the side ditch line of the road to fully intercept any ditch flows.
6. The outflow end of the bar should be fully open and extended far enough beyond the fill edge of the road or trail to safely disperse runoff water onto the undisturbed forest floor.

Specifications for Temporary Water Bars

1. Spacing for temporary water bars should not exceed 100' apart.
2. The depth of a temporary water bar should be 6 inches to 1 foot.
3. Temporary water bars are used for temporary shutdown, for overnight shutdown status or for erosion control during road construction.

SPACING TO USE BETWEEN PERMANENT WATER BARS

Minimum % Grade of Road	Maximum Distance Between Water Bars
Less than 10%	100
10-20	50
20-30	40

Always install a water bar at least 25 feet uphill of stream crossings and landings.

TEMPORARY WATER BARS

OPEN-TOP PIPE CULVERT

Definition--An eight- to 10-inch steel wall pipe with three-inch wide slots cut 24" long along the pipe. **Used to intercept water on roads exceeding 10% slope where broad-based dips are impractical.** Recommended spacing is the same as for a broad-based dip. (Recommend at least 100' apart, but no more than 150' apart.)

Figure 1.--Layout and dimensions of a 20' long open-top pipe culvert.

Open-top pipe culvert.

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Silt-fence application.

Truck haul road (hydro-seeded).

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PIPE CULVERT

Definition--Corrugated metal pipe or other suitable material is placed under truck haul or skid roads.

Purpose--To collect and transmit water flows from side ditches, seeps or streams under haul and skid roads safely without eroding drainage system or road surface.

Conditions Where Practice Applies

Its use is for any size operation where cross drainage of storm water or diversion of small streams is needed for truck haul or skid roads. In such cases, it is a necessary drainage structure for temporary operations, but can be permanent.

Design Criteria

Cross Drainage (Streams):

1. Pipe length should be long enough so both ends extend beyond side slope toes. On truck haul roads, the minimum recommended length is 25'. On skids roads, the recommended minimum length is 20'.
2. When multiple pipes are used in a stream crossing, the space between the pipes should be $\frac{1}{2}$ the pipe diameter, and the fill over the pipe should be at least 1 foot or more. (See diagram on Page 22.)
3. Culvert size must be increased on multiple pipe installations. For example, two 18-inch culverts are required to carry the flow of one 24-inch culvert; two 36-inch culverts will handle the flow of one 48-inch culvert.
4. The minimum diameter pipe on permanent pipe installations should be according to the permanent culvert drainage table on Page 23.
5. The minimum diameter pipe for use is 15"; however, 18" diameter pipe is recommended. Smaller diameter pipes may be used temporarily as long as they are adequate to accommodate the stream channel at maximum flow.
6. Pipe and stream gradient should be the same, with the pipe alignment being the same as the stream course also.

Cross Drainage (Ditching):

1. Pipe length should be long enough so both ends extend beyond side slope toes (25' minimum on truck roads; 20' minimum length on skids roads).
2. Minimum diameter pipe for use is 15"; however, 18" diameter pipe is recommended. Smaller diameter pipes may be used temporarily as long as they are adequate to accommodate the ditch channel at maximum flow.
3. For use in disposing of collected surface water drainage, the culvert gradient should match that of the contributing ditch.
4. Installation should be skewed 30-45° downgrade.
5. Culvert installation should be performed so as to minimize distance from ground at outlet (lower) end.
6. **Erosion protection should be provided for outflows of culverts to minimize erosion below the lower end of the culvert.** It may also be needed on the upstream end of culverts on flowing streams. This protection can be in the form of rip-rap or plastic filter cloth and rip-rap, large stone, hay or straw bales, etc.
7. Water turnouts or diversion ditches can be used to move water away from roadbeds and ditches.

*Note: When pipe diameter smaller than 15" is used, frequent clean-out maintenance is necessary.

CULVERT SPACING GUIDE FOR CROSS DRAINAGE (DITCH DRAINAGE)	
Road Grade (Percent)	Metal Culvert Spacing (Feet)
2-10	200
12	150
14	100
16	50

Multiple Pipe Culvert Installation

Pipe culvert installation for ditching.

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DRAINAGE TABLE*

Estimated culvert diameter needed to carry storm flow from forested areas ranging from 10 to 400 acres and at recurrence intervals of 50 years. Accuracy of values for areas exceeding 100 acres is uncertain. Land use disturbance and soil type above culvert locations can affect water flow peak levels and therefore should be considered when using this chart.

Area acreage	Recurrence interval (50 yr.)
	Inches in Diameter
2-8	15
10	18
20	20
30	24
40	26
50	28
60	28
70	30
80	30
90	32
100	34
125	36
150	38
175	40
200	42
250	46
300	48
350	54
400	54

*Table modified from: Helvey, J. David, and Kochenderfer, James N., 1988. Culvert Sizes Needed for Small Drainage Areas in the Central Appalachians. USDA Forest Service, Northeastern Forest Experiment Station, Parsons, WV. Areas with heavy clay soils may require larger diameter pipes if used as a permanent structure.

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TEMPORARY CULVERT DRAINAGE

For temporary culvert installations, the pipe diameter should be adequate to serve the water channel or ditch channel at maximum flow.

BROAD-BASED DRAINAGE DIP

Definition--A dip and reverse slope in a road surface with an outslope in the dip for natural cross drainage.

Purpose--To provide cross drainage on in-slope truck roads to prevent buildup of excessive surface runoff and sheet erosion.

Conditions Where Practice Applies

Broad-based dips can be used on truck haul and heavily used skid roads having a gradient of 10% or less. They are not to be used for cross draining intermittent or live streams. This practice may be substituted for other surface water cross drain practices (pipe culvert).

Design Criteria

1. Installation takes place following basic roadbed construction.
2. A 20-foot, 3% reverse grade is constructed into the existing roadbed by cutting from upgrade of the dip location and using cut material for the reverse grade.
3. Spacing of broad-based dips should be approximately 100' apart but never exceed 150' apart.
4. Cross drain outslope will be 2-3% maximum.
5. Use rip-rap to control erosion on the loose fill below a dip as needed.
6. The dip and reverse grade section will require bedding with 20 ton of 3-inch crushed stone to avoid rutting of the road surface.

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BROAD-BASED DRAINAGE DIP

Broad-based dip.

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W.VA. DIVISION OF FORESTRY OFFICES

For more information on BMP's, the Logging Sediment Control Act, logger certification and recertification, contact the following:

W.Va. Division of Forestry
1900 Kanawha Boulevard, East
Charleston, WV 25305-0180
(304) 558-2788
FAX (304) 558-0143
www.wvforestry.com

Fairmont Office (Includes counties of Barbour, Brooke, Hancock, Harrison, Marion, Fairmont, WV 26554 Marshall, Monongalia, Ohio, Preston, (304) 367-2793 Taylor, Tucker, Wetzel)
E-mail: wvdofone@ma.rr.com Toll Free 1-866-775-1557

Romney Office (Includes counties of Berkeley, Grant, Hampshire, Hardy, Jefferson, Mineral, Romney, WV 26757 Morgan, Pendleton) (304) 822-4512 Toll Free 1-866-738-4749
E-mail: Romneydof@citlink.net

French Creek Office (Includes counties of Braxton, Clay, Lewis, Nicholas, Pocahontas, Randolph, Upshur, Webster) French Creek, WV 26218 Toll Free 1-866-751-5178 (304) 924-6266
E-mail: wvdof3@mail.state.wv.us

Beckley Office (Includes counties of Fayette, Greenbrier, McDowell, Mercer, Monroe, Raleigh, Summers, Wyoming) 330 Harper Park Drive Suite J Beckley, WV 25801 Toll Free 1-866-271-0201 (304) 256-6775
E-mail: wvdofiv@mail.wvnet.edu

Milton Office (Includes counties of Boone, Cabell, Kanawha, Lincoln, Logan, Mason, Mingo, Putnam, Wayne) P. O. Box 189 878 East Main Street, Rear Milton, WV 25541 Toll Free 1-866-424-5896 (304) 743-6186
E-mail: johnsonk@mail.wvnet.edu

Parkersburg Office (Includes counties of Calhoun, Doddridge, Gilmer, Jackson, Pleasants, Ritchie, Roane, Tyler, Wirt, Wood) 2309 Gihon Road Parkersburg, WV 26101 Toll Free 1-866-288-8117 (304) 420-4515
E-mail: wilsonk@wvnet.edu

WEST VIRGINIA'S LOGGING SEDIMENT CONTROL ACT REVIEW

The following information is designed to give you a basic understanding of the law. If you have questions, contact the nearest office of the West Virginia Division of Forestry.

1. All logging companies, timber buyers, buyers of logs for resale, and other contractors working on a timbering operation MUST have a "Timbering License" for their company. This license costs \$50.00 annually and can be obtained at the State Headquarters of the Division of Forestry (Guthrie Center). Allow two weeks' processing time.

2. All companies and individuals doing business in West Virginia MUST be registered with the State Tax Department (phone: 304-558-3333) and have a West Virginia business number.

Must be in compliance with the West Virginia Workers' Compensation law and supply correct proof of coverage with the timbering license application. (phone: Brickstreet 1-888-498-2667 or Insurance Commission 304-558-3354)

Must be in compliance with the West Virginia Unemployment Compensation Division and supply an original compliance letter with the timbering license application. (Phone: 304-558-1281)

3. Each logging operation MUST be supervised by a "Certified Logger". To become a certified logger, an individual needs to have successfully completed training classes in first-aid, best management practices, and logging safety. Retraining is required every three years or after the second renewal. A card with photo, similar to your driver's license, will be issued stating that you are a Certified Logger in West Virginia. The cost of logger certification is \$50.00 annually for each certified logger and can be obtained at the State Headquarters of the Division of Forestry (Guthrie Center). This is in addition to the license mentioned above. The law requires only one certified logger per logging operation. The certified logger must be on the active logging operation every day.

4. A "Timbering Operation Notification" form MUST be sent