WATERSHED AND STREAMSIDE MANAGEMENT ZONE CHARACTERIZATION IN THE ALLEGHENY PLATEAU OF WEST VIRGINIA

by

Elizabeth Parcell Sharp

Thesis submitted to the Faculty of the Virginia Polytechnic Institute and State University

for the partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

FORESTRY

W. Michael Aust, Chairman
C. Andrew Dolloff
Thomas R. Fox

August 15, 2003
Blacksburg, Virginia

Key Words: Streamside Management Zone, timber harvesting, water quality, West Virginia

Copyright 2003, Elizabeth P. Sharp

WATERSHED AND STREAMSIDE MANAGEMENT ZONE CHARACTERIZATION IN THE ALLEGHENY PLATEAU OF WEST VIRGINIA

Elizabeth P. Sharp

ABSTRACT

The Streamside Management Zone (SMZ) is a cornerstone of forestry Best Management Practices to protect streamwater quality from non-point source pollution resulting from silvicultural operations. However, the exact width and harvest intensity of SMZs that best protects water quality while allowing for commercially valuable timber harvesting has not been determined. The long-term objective of this study is to characterize SMZs and watersheds before and after harvest with different SMZ widths and harvesting intensities in the Allegheny Plateau of West Virginia. The objective this paper is to present the pre-harvest SMZ and watershed characterization. Each of the watershed SMZs were characterized pre-harvest in terms of vegetation, water, soil, carbon, and monetary value within SMZs to predict how silvicultural treatments will affect the future stands. The major overstory tree species found are *Acer saccharum, Liriodendron tulipifera, Fagus grandifolia, Tilia americana, Betula lenta,* snags, *Betula lutea, Fraxinus* spp., and *Acer rubrum*. The overall average streamwater temperature is 13° C. Highest daily temperature occurred in the mid-afternoon and lowest temperatures occurred just before sunrise. Streamwater quality was good, with near neutral pH, low nitrogen content, and high dissolved oxygen. USLE erosion estimates predicted an erosion rate of 2.9 Mg/ha/yr in the SMZ. However, the sediment rods showed an overall accumulation of soil in the SMZ, averaging 173 Mg/ha/yr. This

equates to an average watershed loss of 10.9 Mg/ha/yr. In-stream and SMZ LWD volume was approximately equal at 28 and 33 m^3/ha. Large woody debris was more decayed in the SMZ than in-stream LWD.

ACKNOWLEDGMENTS

Working on my thesis has been more work than I ever imagined it would be, and I would not have been able to do it without the help of many people.

I would like to thank my advisor Mike Aust for his sense of humor, perseverance, and patience while working out the biggest and smallest details of this study with me. Thanks are also due to Andy Dolloff and Tom Fox for serving on my committee and for their assistance and insights into organizing data collection and writing.

I also want to thank Tracey Sherman and Sue Snow for always knowing the answers to my never-ending questions. Tal Roberts also deserves much appreciation for all of his help and patience in helping us building much of the instrumentation for our field work.

The folks at MeadWestvaco have also been instrumental in starting this study. Pat Keyser, Eldon Plaugher, and especially Crystal Bowers have all helped me greatly.

A huge thanks goes out to Tyler Stevenson, Michael Dix, and especially Amy Easterbrook and Kristin Zelenakas for working through all those very long and very hard days of field work—we did it!

My family and friends made all the difference in my graduate work. Their support helped keep me focused on the big picture. Finally, I would like to thank my husband for all of his love and encouragement, without which I never would have finished.

TABLE OF CONTENTS

LIST OF TABLES ..... **viii**
LIST OF FIGURES ..... **xi**
CHAPTER I. INTRODUCTION **1**
Rationale 1
Objectives 2
CHAPTER II. LITERATURE REVIEW **3**
Importance of Riparian Zones 3
Forestry Effects on Water Quality 5
Sediment 5
Stream Temperature 7
Nutrients 8
Silvicultural Chemicals 9
Best Management Practices 9
Definitions and Implementation 9
BMP Effectiveness 11
CHAPTER III. METHODS AND MATERIALS **15**
Site Description 15
Treatments 19
Field Methods 19
In-Stream Measurements 20
Watershed Measurements 24
Lab Methods 26
Water Quality Samples 26
Soil Samples 26
Calculations 27
Large Woody Debris 27
Importance Value 28
Monetary Value 29
Statistical Methods 29

CHAPTER IV. VEGETATION CHARACTERISTICS WITHIN STREAMSIDE MANAGEMENT ZONES IN THE ALLEGHENY PLATEAU OF WEST VIRGINIA 32

Abstract 32
Introduction 33
Methods and Materials 35
Site Description 35
Treatments 38
Field Measurements 40
Calculations 42
Results 44
Overstory Species 44
Midstory Species 46
Lowerstory Species 50
Canopy Cover 50
Age 54
Discussion 54
Vegetation Characterization 54
Successional Changes Resulting from Silviculture 56
Wildlife Considerations 57
Conclusions 57

CHAPTER V. CHARACTERIZATION OF WATER, SOIL, AND CARBON IN FIRST-ORDER WATERSHEDS IN THE ALLEGHENY PLATEAU OF WEST VIRGINIA 59

Abstract 59
Introduction 60
Methods and Materials 62
Site Description 62
Treatments 66
Soils 66
Field Methods 68
Lab Methods 74
Calculations 74

Results and Discussion 77
Water 77
Soil 94
Carbon Inputs 102
Conclusions 111
CHAPTER VI. COMMERCIAL VALUE OF TIMBER LOCATED WITHIN STREAMSIDE MANAGEMENT ZONES IN THE ALLEGHENY PLATEAU OF WEST VIRGINIA 112
Abstract 112
Introduction 113
Methods and Materials 114
Site Description 114
Treatments 117
Field Measurements 118
Calculations 120
Results 124
Stumpage Value 124
Valuable Species 124
Characterization of Valuable Species 129
Regeneration Potential 132
Discussion 132
Factors Affecting the Monetary Value of Species 136
Most Commercially Important Species 136
Attaining the Value of Timber in SMZs 138
Conclusions 139
SUMMARY 140
LITERATURE CITED 142
APPENDIX WATERSHED LEVEL DATA 149
VITA 189

LIST OF TABLES

Table III-1. Average slope, area, harvest area, and stream length to be cut of study sites. B1W1 indicates Block 1 Watershed 1, and so on. C1 indicates Control 1, and so on 18

Table III-2. Decay classes and descriptions for large woody debris, taken from Hyatt and Naiman (2001) 23

Table III-3. Stumpage values for selected species. All information taken from WVU Division of Forestry, except those marked a, which are taken from the Pennsylvania Woodlands Report. Stumpage values calculated on the International Quarter Rule 30

Table IV-1. Average slope, watershed area, percent of watershed harvested, and stream length to be cut of study sites. B1W1 indicates Block 1 Watershed 1, and so on. C1 indicates Control 1, and so on 39

Table IV-2. Relative frequency, relative abundance, relative dominance, and Importance Value of tree species found within all SMZs. Letters indicate a significant difference at alpha = 0.05 in each column..... 45

Table IV-3. Importance value for northern red oak for all blocks. Letters indicate a significant difference at alpha = 0.05..... 47

Table IV-4. Midstory vegetation density for selected species in the SMZs over all blocks and watersheds. Letters indicate a significant difference at alpha = 0.05 .. 49

Table IV-5. Block differences for selected midstory species. Letters indicate a significant difference at alpha = 0.05 for each species..... 51

Table IV-6. Lowerstory layer vegetation density for selected species in the SMZs over all blocks and watersheds. Letters indicate a significant difference at alpha = 0.05 52

Table IV-7. Average block canopy cover for all blocks. Letters indicate a significant difference at alpha = 0.05..... 53

Table IV-8. Age of overstory trees in the SMZs..... 55

Table V-1. Average slope, watershed area, percent of watershed harvested, and stream length to be cut of study sites. B1W1 indicates Block 1 Watershed 1, and so on. C1 indicates Control 1, and so on 65

Table V-2. Decay classes and descriptions for large woody debris, taken from Hyatt and Naiman (2001) 71

Table V-3. Overall, spring, summer, and autumn average streamwater temperature. Letters indicate a significant difference at alpha = 0.05 in each column for both blocks and watersheds..... 78

Table V-4. Selected stream water quality parameters for blocks. Letters indicate a significant difference at alpha = 0.05 in each column for both blocks and watersheds..... 82

Table V-5. Selected streamwater quality parameters for seasons. Letters indicate a significant difference at alpha = 0.05 for season and for site 84

Table V-6. Streamwater chemistry of four similar forested watersheds..... 86

Table V-7. Average pH and calcium concentrations in all watersheds, in Block 4, and in Block 4 Watershed 2, which was limed 88

Table V-8. The Rosgen classification for all blocks and watersheds, including the components used in determining classification 91

Table V-9. The average bankfull streamflow as estimated by the Manning-Chezy equation. Letters indicate a significant difference at alpha = 0.05..... 92

Table V-10. The average stream canopy cover for blocks and watersheds. Letters indicate a significant difference at alpha = 0.05 in each column for both blocks and watersheds..... 93

Table V-11. The average organic matter percent for sites. Letters indicate a significant difference at alpha = 0.05..... 95

Table V-12. Average coarse fragment content of each block. Letters indicate a significant difference at alpha = 0.05..... 97

Table V-13. The average erosion rate, as estimated by the USLE. Letters indicate a significant difference at alpha = 0.05..... 98

Table V-14. Average soil accumulation in the riparian zones, as determined by the sediment rods. Negative numbers indicate soil erosion, rather than soil accumulation. Letters indicate a significant difference at alpha = 0.05 for blocks and for watersheds..... 100

Table V-15. Calculations showing sediment accumulation in the riparian zone and the associated upland erosion 101

Table V-16. Average in-stream large woody debris volume by block. Letters indicate a significant difference at alpha = 0.05..... 103

Table V-17. Average SMZ large woody debris volume by block. Letters indicate a significant difference in the blocks and in the watersheds at alpha = 0.05..... 104

Table V-18. Average litter depth by block of the O_I and O_E layers of the soil. Letters indicate a significant difference at alpha = 0.05 106

Table V-19. Average block stream litter inputs, as determined by litter baskets. Letters indicate a significant difference at alpha = 0.05 108

Table V-20. Average block density of snags. Letters indicate a significant difference at alpha = 0.05 110

Table VI-1. Stumpage values for selected species. All information taken from WVU Division of Forestry, except those marked a, which are taken from the Pennsylvania Woodlands Report. Stumpage values calculated on the International Quarter Rule 121

Table VI-2. Average stumpage values in the SMZs for blocks and watersheds. Letters indicate a significant difference at alpha = 0.05 for the blocks 125

Table VI-3. Stumpage value within SMZs by prescription. Letters indicate a significant difference at alpha = 0.05..... 126

Table VI-4. Percent of stumpage value in SMZ attained by prescriptions. Letters indicate a significant difference at alpha = 0.05 127

Table VI-5. Average density, basal area, DBH, and volume of five commercially valuable species in SMZs. Letters indicate a significant difference at alpha = 0.05 for each column. Ranges given in parentheses 131

Table VI-6. Importance Value of selected overstory species. Letters indicate a significant difference at alpha = 0.05..... 134

Table VI-7. Lowerstory and midstory layer density for selected species. Letters indicate a significant difference at alpha = 0.05 for each column. Ranges for all watersheds given in parentheses..... 135

LIST OF FIGURES

Figure III-1. General study site locations in West Virginia, USA 16

Figure III-2. Idealized map of study watershed showing harvest area, SMZ, and transect 21

Figure IV-1. General study site locations in West Virginia, USA 36

Figure IV-2. Idealized map of study watershed, showing harvest area, SMZ, and transects 41

Figure IV-3. Diameter distribution of all overstory species found in the SMZ 48

Figure V-1. General study site locations in West Virginia, USA 63

Figure V-2. Idealized map of study watershed, showing harvest area, SMZ, and transects 69

Figure V-3. Seasonal and daily streamwater temperature average for all blocks and watersheds. Error bars represent +/- 1 Standard Deviation 79

Figure V-4. Linear regression relating average summer in-stream canopy cover to average summer streamwater temperature, with each data point representing one watershed 81

Figure V-5. Regression relating average erosion estimated by the Universal Soil Loss Equation to average total dissolved solids in streamwater, with each data point representing one watershed 89

Figure V-6. The percentage of the watersheds with soil textures of sandy loam, silt loam, loamy sand, loam, and silt clay loam 96

Figure V-7. Regression relating average transect canopy cover to average litter depth, with each data point representing one watershed 107

Figure V-8. Linear regression relating average in-stream canopy cover to leaf litter inputs to the stream, with each data point representing one watershed 109

Figure VI-1. General study site locations in West Virginia, USA 115

Figure VI-2. Idealized map of study watershed, showing harvest area, SMZ, and transects 119

Figure VI-3. Percentage of SMZs' stumpage value represented by five commercially valuable species 128

Figure VI-4. Diameter distribution for five commercially valuable species (sugar maple, yellow poplar, ash, black cherry, and northern red oak) 130

Figure VI-5. Density of five commercially valuable species, by block. Letters indicate a significant difference at alpha = 0.05 133