RESEARCH/MANAGEMENT
FINDINGS

"When we try to pick out anything by itself, we find it hitched to everything in the universe."

— JOHN MUIR

R QUEEN

Buffer Width and Continuity for Preserving Stream Health in Agricultural Landscapes

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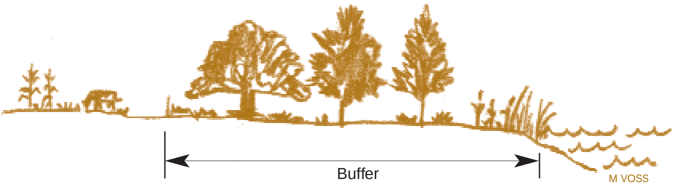
INTRODUCTION

Buffers, undisturbed strips of land between a stream and a pasture or crop field, can help maintain stream health. In 2002, the Wisconsin Legislature considered requiring buffers on most streams when it rewrote the state's nonpoint source pollution control standards. Environmental organizations and others supported the proposed buffer mandate. Debate, however, arose regarding the minimum width and continuity of a buffer necessary to protect stream health. Lawmakers delayed a buffer mandate, asking for research by December 2005 to characterize effective buffers. This report presents a response to that request to define minimum buffer standards. We used fish and aquatic insects as indicators of stream health to determine the minimum buffer width and continuity for stream protection in agricultural landscapes.

METHODS

We selected streams that represented buffers of various sizes, and watershed areas with different levels of agricultural land cover. Sites were scattered statewide to capture the effects of natural environmental factors known to influence streams including geology, temperature, and size. Measures of buffer width and continuity included average buffer width, number of buffer fragments/km, and percent of stream length having greater than a 100m wide buffer (%length>100). Standard error of the average buffer width (SE width) represented variability of the buffer width. The buffer measurements were made on the entire stream network (main stem and tributary streams) upstream from where we sampled fish and aquatic insects. We determined average buffer width by measuring undisturbed vegetation perpendicular to the stream at 500m increments.



Fish and aquatic insects are valuable environmental indicators because they respond to human disturbance over time and at multiple spatial scales. Stress at any time of year can prevent particular species of fish or aquatic insects from colonizing a stream. Furthermore, fish and aquatic insects clearly reflect stress induced at both local spatial (i.e., stream reach) and watershed scales. Standard Wisconsin DNR monitoring methods were used to sample fish at 91 sites and aquatic insects at 77 sites. Stream research using biological data often uses combinations of assemblage attributes to indicate human disturbance. These multimetric assessment tools are called indices of biotic integrity (IBI). In this study, we use the fish-based IBI score (Lyons 1992, Lyons et al. 1996) and the presence of trout in coldwater streams to indicate stream health. We also use the aquatic insect-based IBI (Weigel 2003) and species richness as measures of ecological condition.

The goals of these analyses were to determine how fish IBI, trout presence or absence, aquatic insect IBI, and aquatic insect species richness were related to average buffer width, SE width, fragments/km, and %length>100. Land cover proportions within the watershed (e.g., agriculture, urban, forest) and inherent stream conditions (e.g., watershed slope, temperature,

Bureau of Integrated Science Services • Wisconsin Department of Natural Resources
December 2005 • Issue Fifty-six

size) were also used in the analyses to determine if they explained patterns in the biological data that the buffer variables could not. Simple two-dimensional plots and correlations indicated whether or not the biological data were linearly related to buffer characteristics. Classification tree analysis identified the important independent variables that can be used to predict a categorical response (Breiman et al. 1984). We used this technique to identify thresholds in buffer width, continuity, watershed land cover proportions, and inherent environmental conditions at which stream fish and aquatic insects consistently indicated healthy conditions. We determined the median fish IBI, aquatic insect IBI, and species richness value, and then categorized values below the median as "low" and values above the median as "high." Ultimately, we used classification trees to predict low and high aquatic insect IBI, species richness, fish IBI, and trout presence or absence.

RESULTS

Fish IBI was predicted with 58% accuracy for both low-scoring and high-scoring sites. The primary split between low and high scores was % agriculture within the watershed. Sites having < 32% agriculture and > 8% undisturbed grass within their watershed consistently had high fish IBI scores. Sites having < 32% agriculture, but with < 8% undisturbed grass, also scored high if %length>100 was > 87%. Sites with watershed areas < 15km^2 having > 32% agricultural land cover scored high if soil permeability was < 3.3cm/hour. Sites within large watersheds having high agriculture scored high if SE width was low, meaning that the average buffer width was fairly constant.

Trout absence was predicted with 54% accuracy, whereas trout presence was predicted with 58% accuracy. The primary split between trout absence and presence in coldwater streams was the % sand surficial deposits within the watershed. Trout were present consistently in sites having watersheds with < 27% sand surficial deposits if a third of the stream network had > 100m buffer (i.e., %length>100). Trout were also present consistently in sites having > 27% sand surficial deposits if SE width was low (SE = 2.0).

Aquatic insect species richness was predicted with 58% accuracy at low-scoring sites and with 71% accuracy at high-scoring sites. The primary split between low and high species richness was the number of buffer fragments/km. Sites having < 13 fragments/km consistently had high species richness. Sites having > 13 fragments/km and a variable buffer width (SE width > 3.1) consistently had low species richness.

Aquatic insect IBI was predicted with 74% accuracy at low-scoring sites and with 79% accuracy at high-scoring sites. The primary splitter between low and high scores was average buffer width. Sites having an average buffer width < 37m, and > 61% of the watershed in agricultural land cover consistently had low aquatic insect IBI scores. Sites having an average buffer width > 37m, watershed slope > 4m/km, and < 1.5% urban land cover had high IBI scores (Figure 1). Plots revealed a positive relation between average buffer width and aquatic insect IBI (Figure 2).

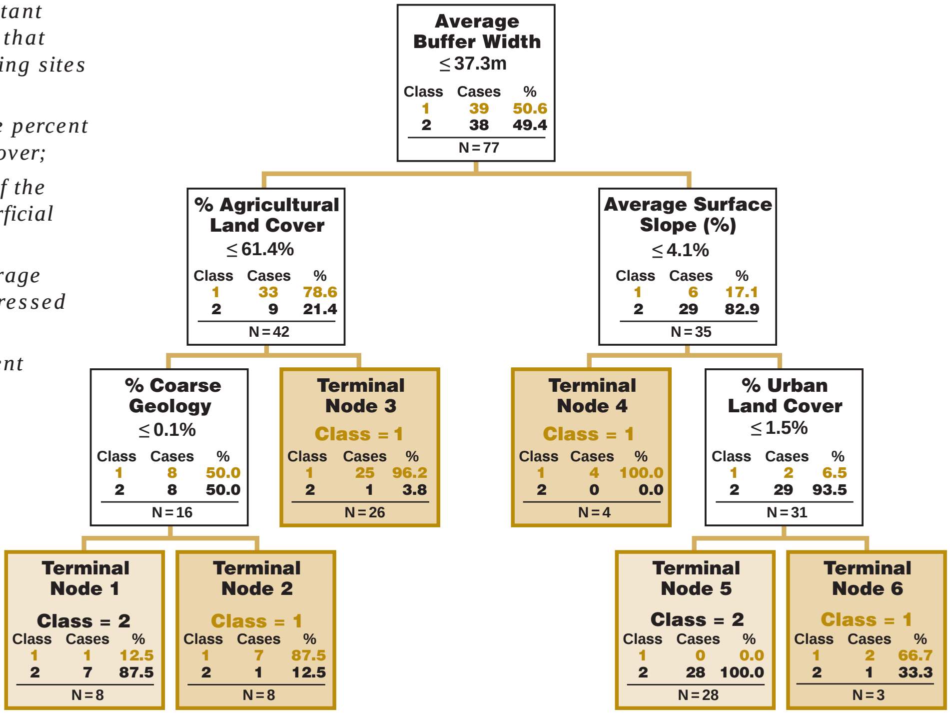


Figure 1. *Classification tree of aquatic insect IBI scores identifying the most important variables and their threshold values that split low-scoring sites from high-scoring sites with 74-79% accuracy.*

"% Agricultural Land Cover" *= the percent of watershed in agricultural land cover;*

"% Coarse Geology" *= the percent of the watershed with coarse-textured surficial geology;*

"Average Surface Slope" *= the average surface slope of the watershed expressed in percent;*

"% Urban Land Cover" *= the percent of watershed in urban land cover;*

Class 1 *= low IBI scores;*

Class 2 *= high IBI scores.*

In reading the tree diagram, go to the left if the case is true (e.g., if average buffer width ≤ 37.3 m then go left to % Agricultural Land Cover).

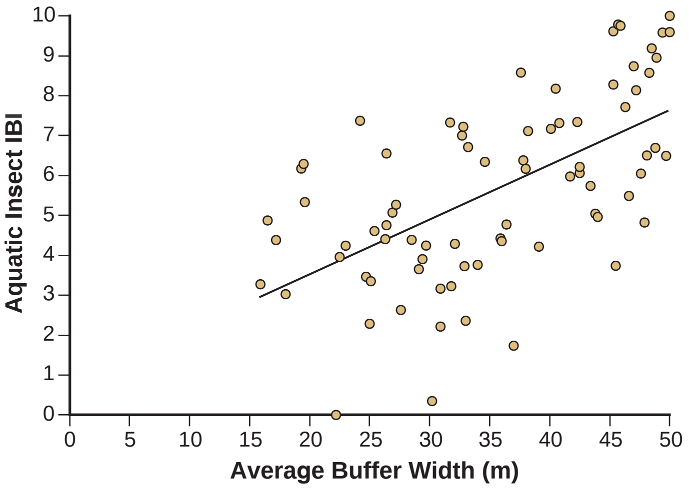


Figure 2. *Plot showing the trend between increasing average buffer width and aquatic insect IBI (R^2=36.8%).*

CONCLUSIONS

This study demonstrated that both width and continuity of undisturbed buffer strips were related positively to stream health. Even streams within highly agricultural landscapes retained healthy ecosystem function if they had a wide buffer maintained for most of their length. We found the following values of buffer dimensions and characteristics consistently associated with stream health as indicated by aquatic insect IBI, aquatic insect species richness, fish IBI, and trout presence:

average buffer width	SE width	fragments/km	%length>100
≥ 37m	3.1	< 13	≥ 31%

Optimal buffer performance appeared consistent with these thresholds in dimensions and characteristics. In addition, our analyses suggested that stream health and buffer characteristics were linearly related, meaning that narrow buffers having some fragmentation had modest effects on curbing agricultural stress, whereas wide buffers without fragmentation had substantial effects.

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Undisturbed strips of vegetation separating agricultural lands from streams can help maintain stream health.

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Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, WI 53707

Printed on recycled paper.

PUB-SS-756 2005

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Editor: Dreux J. Watermolen
Graphic Design: Michelle E. Voss