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## Occurrence of Windthrow in Forest Buffer Strips and its Effect on Small Streams in Northwest Washington

### Abstract

Retaining streamside buffers has become a common way of protecting streams during timber harvest operations. Trees within forest buffers help stabilize streambanks, provide shade, and serve as a source of large woody debris. However, buffer trees are often subject to increased levels of windthrow which may impair some buffer functions. Forty (40) forest buffers bordering small, non-fish bearing streams in northwest Washington were assessed to quantify the level and in-stream effects of windthrow 1 to 3 years after clearcut harvest of adjacent timber. On average, windthrow affected 33 percent of buffer trees and ranged from 2 to 92 percent across the 40 sites. Sixty-seven percent of windthrown trees fell to the north, northeast, or northwest, while only three percent of the total fell towards the south. Large woody debris present in streams at the time of harvest was significantly larger than debris recruited as a result of buffer windthrow (t-test;  $p < 0.01$ ). Windthrow increased total in-stream large woody debris piece counts by 52 percent. Seventy-five percent of in-stream large woody debris pieces recruited to streams post-harvest were suspended above the bankfull channel while four percent stored sediment. Seventeen percent of uprooted trees delivered sediment to stream channels. The average volume input was 0.16 cubic meters per uprooted tree and 0.48 cubic meters per 100 meters of stream channel at 39 sites where mass wasting did not occur. At most sites, the volume of sediment input to streams was small relative to the amount stored behind obstructions. Large woody debris was the primary component of 93 percent of in-stream obstructions which stored sediment.

### Introduction

Tree mortality resulting from windthrow (uprooting and stem breakage) has been a concern to forest land managers in the Pacific Northwest for most of this century. From a timber production perspective, windthrown trees represent an economic loss. These trees lose commercial value rapidly and salvage operations are often costly. Additionally, if not salvaged, insects attracted to the dead trees can spread into surrounding timber. From a broader ecological perspective, windthrow is a natural occurrence, and downed trees contribute to forest and stream productivity.

Since the 1970s, the establishment of forest buffers has increasingly become a way of protecting streams during timber harvest operations. A common rationale for retaining streamside buffers is the assumption that they can provide many of the same functions as an intact forest. However, trees within buffers are subject to increased wind exposure and significant amounts of windthrow can impair some buffer functions. The net effect of windthrow on streams is often debated from water quality, fish habitat, channel morphology and legal liability perspectives.

State and private forest land managers in northwest Washington have established buffers which

exceed state Forest Practice rules on many small, non-fish bearing streams during the past several years. Instances of severe windthrow in these buffers have caused managers to question the practice of retaining "non-required" buffers. This study was undertaken to develop quantitative information regarding the fate and function of second-growth forest buffers retained along small, non-fish-bearing streams.

Published studies dating from the 1950s document a wide array of site, tree and forest stand characteristics that influence windthrow occurrence in Pacific Northwest forests. Regrettably, data are lacking to support the cause-and-effect relationships reported by many of those studies (Rollerson 1982). Early windthrow studies in Washington and Oregon focused on mortality along clearcut harvest boundaries and offered recommendations for cutting-line placement to reduce windthrow (Ruth and Yoder 1953; Gratkowski 1956; Steinbrenner and Gessel 1956). Research emphasis on windthrow shifted to streamside buffers in the 1970s as buffers became more common on public and private forest lands (Moore 1977; Hobbs and Halbach 1981; Steinblums et al. 1984; Andrus and Froehlich 1988; Sherwood 1993; Timber, Fish and Wildlife 1994; Mobbs and Jones 1995).

Streamside trees can exert significant influence on channel morphology and fluvial processes in small, low-order streams of the Pacific Northwest (Naiman et al. 1992). Standing trees and/or their root systems help retard streambank erosion and maintain stability of stream-adjacent hillslopes (Sullivan et al. 1987). Fallen trees and limbs supply in-stream woody debris which helps store sediment, dissipate streamflow energy, and create channel complexity. Despite these positive effects of woody debris on channel morphology, our understanding of the role of riparian and stream-adjacent forests in supplying wood has developed only recently (Bisson et al. 1987).

In this study, we characterized tree condition, large woody debris function, and stream sediment input and storage within forty (40) streamside buffers and associated non-fish bearing streams 1 to 3 years following clearcut harvest of adjacent second-growth timber. The objectives of this study were to:

- 1) quantify the amount and type of tree windthrow by species;
- 2) assess the abundance and function of in-stream large woody debris;
- 3) quantify the volume of in-stream sediment stored in discrete accumulations or wedges and the volume of sediment delivered to stream channels from uprooted trees.

## Methods

### Site Selection

State and private forest land managers were asked to identify potential study buffers adjacent to small streams on the lower, west slope of the North Cascades within the Stillaguamish, Skagit and Nooksack river basins of northwest Washington. From these potential sites, we randomly selected 40 buffers that met the following criteria:

- 1) non-fish bearing stream >1 meter average width;
- 2) buffer had a continuous, 180 meter or longer reach within the harvest unit;
- 3) clearcut harvest of adjacent timber occurred during the previous three years;
- 4) buffer trees were retained on both sides of the stream.

While the large majority of buffers had no removal of live trees, harvest of selected larger conifer trees did occur at three sites. The buffers were typical of merchantable, second-growth forest stands in northwest Washington, ranging in age from 40 to 60 years.

### Inventory Procedure

Field work was completed during the summer of 1996. Data were collected within a 150 meter reach randomly located within each buffer. Total buffer length rarely exceeded 300 meters, thus the study reach usually included at least half of the total buffer length ( $\geq 50\%$  sample).

Each study reach was divided into 15 meter segments. Channel gradient was measured for each segment; bankfull channel width, buffer width (slope distance), and adjacent hillslope gradients were measured at each segment node (11 locations). Buffer width and hillslope gradients were measured perpendicular to stream orientation. The "forming structure" associated with each in-stream sediment wedge was determined and stored sediment volume was estimated based on surface area and step height. Four classes of forming structures were identified: (1) pre-harvest large woody debris, (2) post-harvest large woody debris, (3) combination of pre- and post-harvest large woody debris, or (4) bedrock and/or boulder.

In-stream large woody debris >10 centimeters in diameter and >1.5 meters in length was tallied. Hydraulic function (sediment storage, bank protection, bank erosion, channel roughness, or bridging) and time-of-entry (pre- or post-harvest) was recorded for each piece lying within the vertical projection of the bankfull channel. Woody debris pieces outside this zone (i.e., on adjacent hillslopes) were not included in the inventory. Post-harvest debris pieces were differentiated from pre-harvest pieces based primarily on physical condition. It was assumed that pieces in more advanced stages of decay had been recruited to the channel prior to harvesting, while pieces with intact bark and/or foliage were of post-harvest origin (i.e., 1 to 3 years since time of recruitment). In addition, the degree of embeddedness exhibited by a particular piece was often used as an indicator of recruitment timing.

All standing, uprooted, and broken trees 15 centimeters diameter at breast height (DBH) and larger were inventoried. Downed trees that