

**Reasonable Assurance of Windfirmness
Guidelines
Version 2.0**

Tongass National Forest

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Technical Contact: Dennis J Landwehr

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Changes from Version 1.0.

Version 2.0 incorporates stream habitat survey data metrics published by Bryant et al (2004). The data from Bryant et al (2004) will essentially updates the values reported in the Region 10 Aquatic Habitat Management Handbook. Version 2.0 also corrects some typographical grammatical errors in Version 1.0.

Introduction

The Tongass National Forest Land Management Plan (TLMP) Riparian Standards and Guidelines (S&Gs) established buffer width design elements for riparian area protection based on stream process groups. Stream process groups are based on the geomorphic characteristics of the stream channel and riparian area. For many process groups the design elements are followed by the phrase “Manage an appropriate distance beyond the no-harvest zone to provide for a reasonable assurance of windfirmness of the Riparian Management Area (pay special attention to the area within one site-potential tree height on the Riparian Management Area).” The area beyond the no-harvest zone has become known as the RAW zone, short for Reasonable Assurance of Windfirmness.

Purpose and Need

The forest plan did not provide any direction or guidance for designing a RAW zone or determining if standing timber would be needed in a RAW zone. The plan did state that implementers should pay special attention to the area within one site-potential site tree height of the Riparian Management Area (RMA). Interdisciplinary teams have expressed a need for some guidance as to the conditions that would require a buffer that extends into the RAW zone. It is the intent of this paper to summarize the existing buffer stability monitoring data on the forest, review the pertinent literature, and describe a strategy for assessing windfirmness on a site specific basis.

Objectives

This paper will summarize the literature and describe windthrow indicators and site factors to consider when designing buffers. Local buffer stability monitoring data and forest plan direction will also be summarized. A Windthrow Assessment Strategy for interdisciplinary teams tasked with designing RAW zones for riparian management areas will be described. An interim evaluation tool for assessing success of buffer stability will also be described.

Factors to Consider

Meteorological factors

Southeast Gales are the most damaging fall and winter storms that occur in southeast (SE) Alaska. These storms originate in the northern Pacific and rotate counterclockwise as they move northeast across SE Alaska (Harris, 1989). Due to this dominant storm track the southeast and southwest outer edges of islands are more susceptible to windthrow than northeast edges of the islands (Harris 1989, Moore 1977, Kramer 2000, Nowacki and Kramer 1998). Inland stream buffers may be less susceptible to windthrow (Andrus and Froehlich 1992, Kramer 2000, Kramer et. al. 2001, Harris 1989)

Localized Bora or Glacier winds have been known to cause windthrow in forests of SE Alaska. The Bora or Glacier winds are associated with major river valleys penetrating the coast range, or with the temperature difference associated with ice fields (Harris 1989, Moore 1977). The Stikine River Valley near Wrangell and Taku Inlet near Juneau are two examples of areas where localized damaging winds occur (Harris 1989, Kramer 2000).

With wind often comes rain (Harris 1989, Moore 1977). Saturated soil conditions reduce soil strength and increase the chance for windthrow (Moore 1977, Harris 1989).

Topography

Wind tends to travel in laminar flow like a river (Foreman and Godron 1987, Harris 1989). Wind speed increases when the flow is constricted by topography or other obstructions (Moore 1977, Harris 1989, Alexander 1964, Andrus and Froehlich 1992, Foreman and Godron 1987, Kramer et. al. 2001). Where the local topography impedes or constricts wind flow there will be more blowdown (Harris 1989, Moore 1977, Alexander 1961, Andrus and Froehlich 1992).

Moore (1977) suggests that steep-walled valleys with sideslopes greater than 50 to 70 percent slope may offer protection to trees left in streamside buffers on the valley floor. Grizzell and Wolff (1998) found that broad U-shaped valleys offered little protection to stream-side buffers left in the valley bottom. Alexander (1964) suggests avoiding leaving trees on ridgetops or saddles. Because wind speed increases as it flows around ridges or valley corners, westerly or easterly aspects near the ends of ridges may be more susceptible to windthrow from turbulent air at that location (Harris 1989).

Stand and Soil Factors

Wind regenerated stands have been identified in SE Alaska (Harris 1989, Nowacki and Kramer, 1998, Kramer 2000, Kramer et. al. 2001). Wind regenerated stands can be identified because they often have an even-aged stand structure with one or two cohorts (Nowacki and Kramer 1998, Kramer 2000, Kramer et. al. 2001). In these stands pit and mound topography is common (Kramer et. al. 2001, Kramer 2000, Nowacki and Kramer 1998, Harris 1989, Moore 1977). Moore (1977) cautions that some mounds can form as

a result of windsnap and stump decay, and may not be indicative of a windthrown tree. Soil excavation may be necessary.

Conversely Kramer 2000, Kramer et. al. (2001) and Nowacki and Kramer (1998) describe stands on wind protected slopes as having all ages of trees represented and gap-phase stand dynamics prevail. Stands with south exposures will be more susceptible to windthrow (Nowacki and Kramer 1998, Kramer 2000, Kramer et. al. 2001, Moore 1977). Kramer et. al. (2001) suggests that stands on slopes exposed to south facing azimuths between 160 and 220 degrees would be more susceptible to windthrow from cyclonic (southeast gale) wind events.

Open grown trees are naturally more windfirm than trees in dense even-aged stands (Moore 1977, Harris 1989, Alexander 1964). Often trees growing on the shoreline are windfirm because they have been exposed to storm winds and are essentially open-grown (Harris 1989). For the same reason dominant trees in a stand may be more windfirm than lower class trees (Alexander 1964, Harris 1989).

Root damage, typically by fungi, can make a stand more susceptible to windthrow (Harris 1989, Moore 1977, Alexander 1964). Harris (1989) suggests that older trees will be more susceptible as the limb and leaf to root ratio increases. Alexander (1964) and Harris (1989) both suggest that damaged trees may be more susceptible to windthrow for the same reasons (loss of root volume or area).

Stand type and soil drainage help determine windfirmness of the stand (Harris 1989, Moore 1977, Alexander 1964, Andrus and Froehlich 1992). Effective rooting depth (Moore 1977) can be limited by depth to bedrock or dense till layers (Moore 1977, Harris 1989, Alexander 1964, Grizzell and Wolff 1998), high water tables (Alexander 1961, Moore 1977), cemented soil layers (Moore 1977), or fine textured soils (Moore 1977). Alexander (1964) suggests that soils with a depth of more than 12 to 24 inches would be more windfirm than shallower soils. Fractured bedrock may improve windfirmness (Moore 1977).

Harris (1989) suggests that trees growing on mounds may be more windfirm than trees in hollows or pits because of better soil drainage. Harris also reports that stilt-root trees may be more susceptible to windthrow.

Conifer trees are more susceptible to windthrow than deciduous trees (Alexander 1964, Andrus and Froehlich 1992). Hemlock trees are often shallow rooted and more susceptible to windthrow (Moore 1977, Alexander, 1964). Spruce trees tend to root more deeply and may be less susceptible to windthrow, although the deep rooting characteristic is site dependent (Harris 1989).

Buffer Characteristics

Because wind travels in laminar flow the physical characteristics of the buffer and location of the buffer on the landscape will determine the amount of resistance to laminar flow created by the buffer. Resistance to laminar flow creates turbulence, including

increased windspeed and changes to wind direction (Foreman and Godron 1987). Buffers parallel to windflow may be more windfirm than buffers perpendicular to windflow (Andrus and Froehlich, 1992, Moore 1977, Alexander 1964). Conversely, Grizzell and Wolff (1998) found that buffer orientation was not a factor in the amount of windthrow in their study buffers in the northern cascades.

The size of the adjacent opening (clearcut) may be a factor in the amount of windthrow (Alexander 1964, Moore 1977). Harris (1989) found no consistent relationship between size of clearcut and the amount of blowdown experienced on the edge of the clearcut. He suggested all clearcuts on his study area (Prince of Wales Island) were big enough to influence wind movement and the stability of trees on the edges of clearcuts.

Narrow buffers may be more susceptible to windthrow than wider buffers (Harris 1989). Foreman and Godron (1987) state that porous windbreaks are better than dense windbreaks at maintaining laminar flow. A narrow buffer with windfirm trees that is somewhat porous may be more windfirm than a wider, dense buffer. This observation may only be applicable to very small streams where porosity in the retained buffer can be effectively achieved. On larger streams the landform and stand characteristics will probably not be conducive to leaving a porous windfirm buffer. (Note: Foreman and Godron summarized principles of windflow pertaining to windbreaks left around structures.)

The height of the trees left can be an important factor in determining windfirmness (Harris 1989). A windbreak that has taller trees toward the middle of the windbreak will be better at maintaining laminar flow than a buffer with taller trees on either edge (Foreman and Godron 1987). Because many of our buffers are centered on streams, and streams are often incised into a hillslope, designing a buffer that is taller in the middle and shorter on the edges may be difficult.

Many of the stand, tree, and soil characteristics mentioned above can be used when determining if individual trees within a streamside buffer will be windfirm. Location of buffers in relation to the surrounding topography and prevailing winds is probably the most important factor determining the susceptibility of the buffer to wind damage (Moore 1977, Alexander 1964).

Potential Impacts of Windthrow in Streamside Buffers

Moore (1977) and Harris (1989) described potential impacts to streams as blockage of fish habitat, loss of shade, and sediment introduction. Andrus and Froehlich (1992) found only 12 percent of windthrown trees in streamside buffers were sources of sediment to the stream. They also noted that root wads away from the streambank were generally not sources of sediment. Andrus and Froehlich noted that increases in sediment resulting from windthrow were probably not high enough to be detected.

Grizzell and Wolff (1998) found results similar to Andrus and Froehlich (1992). They report that 17 percent of windthrown trees in streamside buffers were sediment sources to the stream. They found that most sediment delivered to the stream from windthrow was

from root wads within 3 meters of the stream. They also noted that the amount of sediment delivered by windthrown trees was minor when compared to the amount of sediment stored behind the woody debris in the stream. With the exception of one small landslide associated with windthrow, Grizzell and Wolff found that windthrow in stream buffers is generally not a significant source of sediment.

Windthrow is a natural process for delivering woody debris to stream channels. Andrus and Froehlich (1992) found that one third of the windthrown trees on their study reaches were suspended above the stream channel and one fifth of the trees had tops below the high water mark. Debris dams were once considered detrimental to stream function and fish habitat (Moore 1977, Harris 1989). However, woody debris is now recognized as beneficial to fish habitat (Harris 1989). In non-fish bearing streams woody debris is recognized as necessary for proper ecological functions in those streams (May and Gresswell 2000, Gomi et. al. 2003).

Wood in streams controls routing of water and sediment, dissipates stream energy, shapes pools, and other habitat features, provides substrate for biological activity (Maser and Sedell, 1994). In high gradient contained streams wood functions to entrain sediment, stabilize banks and longitudinal profiles, and create stream complexity. Where wood is absent from high gradient contained streams, the stream becomes a bedrock channel with no ability to store sediment and thus a chronic sediment producer versus a stream that produces sediment episodically (May and Gresswell, 2000).

Too much wood, especially fine woody debris, in a high gradient contained streamcourse can lead to debris dams and debris torrents (Swanston 1974, Bishop and Stevens 1964, Chatwin et. al. 1994).

At 40 stream buffer sites Grizzell and Wolff (1998) found that windthrow impacted 33 percent of the trees in the buffers. Andrus and Froehlich (1992) found that 20 percent of trees in buffers were windthrown at 13 sites. Most authors agree that most windthrow in stream buffers will occur the first few years after timber harvest and that windthrow will diminish the longer the buffer is standing (Andrus and Froehlich 1992, Moore 1977, Alexander 1964). Kramer et. al. (2001) and Kramer (2000) found that in wind regenerated stands blowdown was likely to occur repeatedly over 100 year plus time scales.

Blowdown in riparian management areas is a natural process. None of the researchers cited here attempted to say how much windthrow in streamside buffers was too much. The effect of large amounts of windthrow on stream functions over a longer time scale has not been studied. Reeves (1995) stated that the two primary differences between natural disturbance processes and those associated with land management activities are the periodicity or temporal scale of the disturbances and the extent of the disturbances. Generally, land management activities involve disturbance processes that are frequent and of low intensity whereas natural disturbance processes are infrequent but greater intensity.

When determining the degree of measures to be taken to make a streamside buffer windfirm the resources at risk need to be considered. Resources that may warrant additional attention when designing windfirm buffers include domestic and public water supplies and streams associated with fish hatcheries or karst and cave resources.

Tongass buffer Stability Monitoring Results to date

The 1997 Tongass Forest Plan listed buffer stability monitoring as one method of BMP effectiveness monitoring. The monitoring of buffer stability involves annually measuring the amount and characteristics of windthrow within each Riparian management Area (RMA) using low altitude aerial images. The amount of windthrow is measured as the number of windthrown trees compared to the total number of originally standing trees within a RMA. The monitoring began in 2000 and is ongoing. Currently 133 RMAs are being monitored, of this group 103 RMAs have been revisited at least once since the baseline conditions were established following timber harvest. The results presented here are based on the 103 resampled RMAs.

Twenty-two RMAs experienced some windthrow. In nine RMAs windthrow exceeded 10 percent of the trees in the RMA. Windthrow ranged up to 73 percent in a RMA. Six RMAs had windthrow exceeding 20 percent of the RMA. Three RMAs had windthrow in excess of 50 percent of the RMA. Most RMAs in the dataset are on high gradient contained (HC) process group channels. The RMAs experiencing the most windthrow are also located on high gradient contained channels.

On average only 3.8 percent of trees were windthrown in all RMAs combined. Within the HC process group windthrow associated with Class III streams averaged 4.5 percent (n = 69).

As part of the buffer stability monitoring unit implementation cards were reviewed for buffer width information and RAW zone characteristics. Most unit cards did not include RAW zone prescriptions, widths or characteristics. This lack of data is an impediment to assessing the effectiveness of RAW zones in stream buffer stability. Determining the presence or absence of RAW zones from low altitude digital images collected as part of this monitoring has not been done and may not be possible.

In the absence of information on which RMAs have RAW zones and the characteristics of them, a comparison was made of the amount of windthrow in: 1) RMAs that have timber harvest on each side of their associated stream to RMAs that have timber harvest on only one side of their associated stream and, 2) RMAs that are associated with single-age clearcut management to RMAs associated with some form of partial harvest multiple-age management.

The retention of trees in a partial harvest, multiple-age management harvest unit may act as a RAW addition to an RMA. Similarly, un-cut areas next to one side of an RMA may act as a RAW addition to that RMA. Although the mean values for windthrow are

slightly less in RMAs with timber harvest on only one side of the RMA (3.3%) versus RMAs with harvest on two sides (4.8%) or where partial harvest occurs adjacent to the RMA (3.5%) versus clearcut adjacent to the RMA (3.9%), the mean values are not significantly different at 95 percent confidence. The partial harvest units vary dramatically in the amount and pattern of tree retention and further stratification of harvest units by these variables may indicate a significant difference.

Due to several issues, primarily lack of RAW buffer documentation on unit cards, the data reported here is not yet conclusive in determining if RAW zones are effective at reducing windthrow within RMAs. RMAs adjacent to partial harvest prescriptions or one-sided buffers may experience less windthrow. Local knowledge suggests there are few RAW zones in the group of 103 RMAs monitored to date.

The data indicates there is potential for catastrophic windthrow in some RMAs. Nine of 103 RMAs (9%) have windthrow in excess of 10%. Assuming there are few RAW zone additions in the 103 buffers monitored to date, it appears those RMAs with higher rates of windthrow could benefit from a RAW zone prescription. Based on the data the need for RAW zone buffers may be limited to areas where windthrow concerns are high. The challenge is to better define where the windthrow risks are high.

The RMA stability data is currently limited to a short time period. Longer term monitoring of buffer stability is recommended to evaluate the effects of larger scale windstorm events. RAW zones can be confused with wildlife leave areas or trees that are left for reasons other than to reduce windthrow potential. Documentation of the reasons for retained trees should be explained on the unit cards.

Plan direction

For most stream process groups, the forest plan riparian standards and guidelines require us to:

“manage an appropriate distance beyond the no-harvest zone to provide for a reasonable assurance of windfirmness of the Riparian Management Area (pay special attention to the area within one site-potential tree height of the Riparian Management Area).”

The forest plan left a lot of flexibility when interpreting the RAW guideline. In an area where windthrow risk is low it may be appropriate to leave no trees in the RAW zone. Where windthrow risk is high it may be appropriate to leave trees well beyond the distance of one site-potential tree from the no-harvest buffer.

The objectives and desired conditions are listed in the forest plan by stream process group. In summary the goal is to maintain natural stream functions. For all process groups except High Gradient Contained the objectives pertaining to large wood are: “Activities should not accelerate surface erosion or mass wasting. Maintain near natural quantities of large wood by assessing the site’s old-growth type and managing for the

natural frequency and size distribution for large downed wood and standing trees. In the stream channel meet the natural range of aquatic habitat features for large wood size and distribution, and pool size and frequency.” For High Gradient Process Group streams the objectives are: Activities should not accelerate sideslope surface erosion or mass wasting. Maintain some in-stream large wood structure over the long-term where important for downstream channel processes which require wood as a component of natural debris torrents.” Quantifiable objectives from the Region 10 Aquatic Habitat Management Handbook and Bryant et al (2004) are included in Appendix A of this report.

Reasonable Assurance of Windfirmness Assessment Strategy

Due to the site specific conditions associated with windthrow risk assessments, it is difficult to prescribe RAW buffer widths for generic situations. Windthrow risk should be assessed by a sub-IDT that includes at a minimum the IDT silviculturist. The silviculturist or sub-IDT should be familiar with the windthrow literature cited in this report. The following documents are especially pertinent to southeast Alaska; Harris 1989, Moore, 1977, Kramer et. al 2001, Kramer 2000, and Nowacki and Kramer 1998.

When assessing windthrow risk the sub-IDT should consider the concepts presented in this report. Special attention should be given to the direction of prevailing winds or local winds and the location of wind-generated stands. An understanding of the way wind moves over and around the topography in and adjacent to the area in question is critical. Evidence of windthrow in and around the area in question should also receive high consideration. Look at existing clearcut edges or other buffers with location and orientation similar to the proposed buffer. In most cases edges of islands will have higher risks than interior valleys (Harris 1989, Kramer et. al. 2001, Kramer 2000). Multiple factors at a given site indicate a high probability of windthrow (Moore 1977). For Kuiu and Zarembo Islands Kramer et. al. (2001) created a windthrow model that explains much of the variability in windthrow locations on those islands.

The sub-IDT should consider the resources at risk in the buffered stream and downstream. Resources at-risk that may warrant a wider streamside buffer include; a public and domestic water supply, a fish hatchery water supply or karst and cave resources.

The sub-IDT should consider Tongass monitoring data which indicates that RAW buffers may only be needed where the risk of windthrow is high. This observation is based on the assumption that few RAW buffers are present in the 103 RMAs monitored and analyzed to date.

When designing RMA buffers many of the concepts presented in this report may be used to determine if individual trees will be windfirm.

The Tongass monitoring data indicates that IDTs have not been documenting the consideration or use of RAW buffers on timber sale implementation cards. This lack of

documentation is a serious impediment to understanding the effects of RAW buffers on RMA stability. The sub-IDT should document the consideration and use of RAW buffers and other leave areas designed to reduce windthrow within RMAs.

Evaluation of buffer stability

The Tongass buffer stability monitoring uses the following evaluation tool to assess the performance of riparian management areas. (From the Tongass Monitoring Protocol Guidebook, 2000.)

“The condition of stream buffers will be assessed by measuring the change in area of canopy opening of the RMA from immediately following harvest activities to periods of 1, 2, 3, 4, 5, 10 and 15 years following harvest. Initial analysis will include validating the null hypothesis H_0 : there is no difference between the mean change in area of canopy opening of the RMA’s adjacent to harvest units and that of similar riparian areas not adjacent to harvest units. If the null hypothesis is tenable then our current prescriptions established to maintain the RMA in mostly natural conditions will be considered successful. If the null hypothesis is rejected then additional analysis will be preformed to establish the correlation between the dependent variable (% change in area of canopy opening) and the independent variables, management prescription, and blowdown hazard class (Kramer M.E.1997) and time since harvest.”

In other words the goal is to keep the percent canopy opening in the RMA similar to the percent canopy opening in the RMA adjacent to the harvest unit. Windthrow in the RMA should not be exacerbated beyond the windthrow in the surrounding unharvested RMA. To date this evaluation has not been made (USDA FS 2004). Windthrow in control areas has not been documented.

Based on the Tongass buffer stability monitoring results to date accelerated windthrow may be occurring in some RMAs. These RMAs may not be meeting the initial evaluation criteria in the protocol guidebook. Forest Plan Objectives of “maintaining near-natural quantities of large wood by assessing the site’s old-growth type and managing for the natural frequency of and size distribution for large, downed wood and standing trees” that apply to all process group except the high gradient contained process group may or may not be met. For the High Gradient Contained Process Group the objectives include “maintain some in-stream large wood structure over the long-term”.

An evaluation of whether or not forest plan objectives have been met for streams with RMAs that have incurred some windthrow is possible based on the typical channel characteristics documented in the Region 10 Aquatic Habitat Management Handbook and Bryant et al (2004). (See Appendix A of this report.) Additional monitoring and evaluation is needed to determine if stream channel objectives are met in RMAs with high amounts of windthrow.

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Appendix A

Quantifiable objectives excerpted from the Region 10 Aquatic Habitat Management Handbook and Bryant et al (2004).

3. Fish Habitat. Achieving the broad objectives for aquatic habitat management requires that additional objectives be identified for specific habitat parameters. The Anadromous Fish Habitat Assessment establishes fish habitat objectives in terms of desired physical and biological conditions that can be precisely measured and described. These habitat objectives, as stated in AFHA, “are a first approximation of scientifically based indicators of healthy, fully functioning aquatic systems on the Tongass National Forest.” Initially developed on the Tongass National Forest, these objectives also serve as interim Regional objectives that will be adjusted as new information (e.g., additions to the resource data base) and improved understanding of habitat relationships and disturbance processes become available.

From the Riparian Area Restoration section

Large wood plays an important role in stabilizing banks, moderating the transport of sediments downstream, and forming pools. How a piece of wood functions in a stream depends on its size relative to the size of the stream. In very large rivers, a small piece of wood may not stay in place as long as a big piece or a cluster of pieces, and is not likely to play as important a role in bank stabilization and pool formation. Large wood pieces big enough to have important geomorphic functions are called key pieces. The size of a key piece depends on the size of the stream in which it is found (42.14 - Exhibit 01).

42.14 - Exhibit 01

Large Woody Debris “Key Piece” Minimum Size Criteria by Stream Channel Width

Average Channel Bed Width	Diameter	Stem Length	Rootwad Diameter and Length
(meters)	(meters)	(meters)	(meters)
0 - 4.9	0.3	> 3	> 1
5 - 9.9	0.3	> 7.6	> 3
10 - 19.9	0.6	> 7.6	> 3
≥ 20	0.6	> 15	> 3

Tables 1, 2 and 8 are taken from Bryant et. al (2004)

Table 1. Average, maximum and minimum for eight R10 habitat parameters.

Habitat Attribute	Process Group=FP		Process Group=MM		Process Group=MC_LC		Process Group=HC	
	Harvested		Harvested		Harvested		Harvested	
	NO	YES	NO	YES	NO	YES	NO	YES
WD	28 (79-9)	29 (66-5)	14 (53-2)	21 (45-11)	19 (60-4)	27 (86-4)	8 (14-2)	11 (15-5)
TLWD/M	.40 (1.68-0.1)	.36 (1.11-0.05)	.34 (.71-.08)	.23 (.32-.03)	.24 (.42-.13)	.20 (.62-0)	.32 (.48-.23)	.26 (NA)
TKWD/M	.11 (.25-.02)	.12 (.30-.02)	.11 (.27-.01)	.002 (NA)	.10 (.29-.01)	.07 (.19-.02)	.26 (.44-.07)	NA
POOL/KM	41 (99-8)	30 (64-5)	58 (164-11)	44 (127-18)	44 (80-9)	38 (181-2)	71 (136-44)	76 (112-50)
POOL SPACE	3.98 (32.4-0.04)	2.70 (11.5-0.02)	0.97 (9.03-.03)	1.18 (3.08-0.02)	2.21 (16.3-.19)	4.62 (45.9-.07)	0.49 (.77-.29)	0.20 (.4-.11)
RPD/CBW	0.05 (.13-.03)	0.04 (.09-.03)	0.09 (.16-.04)	0.07 (.18-.04)	0.07 (.25-.03)	0.07 (.13-.02)	0.08 (.13-.05)	0.10 (.18-.06)
D50	38 (109-6)	36 (68-10)	55 (122-17)	86 (210-25)	117 (319-17)	71 (168-23)	107 (211-29)	345 (1000-93)
PLNGTH/m	.45 (.80-.11)	.47 (.80-.02)	.28 (.43-.10)	.44 (.80-.15)	.29 (.51-.01)	.49 (1.01-.13)	.24 (.58-.03)	.36 (.51-.21)

N.B. these data are based on main channel habitat data only, does not include side channel habitat data!!!! (d.kelliher confirmed by Brenda Wright on 11/13/03).

Table 8. Percentiles for each of eight stream parameters. (NA=not available)

Habitat Attribute	Percentiles	Process Group=FP		Process Group=MM		Process Group=MC_LC		Process Group=HC	
		Harvested		Harvested		Harvested		Harvested	
		NO	YES	NO	YES	NO	YES	NO	YES
WD	25	18.0	18.6	5.8	13.9	7.3	11.5	6.1	9.6
	50	23.5	23.8	10.7	18.4	14.8	18.5	7.9	11.5
	75	33.6	38.4	16.1	23.7	22.4	39.9	10.3	12.7
TLWD/M	25	.23	.16	.21	.19	.17	.08	.24	NA
	50	.33	.25	.30	.25	.21	.14	.26	NA
	75	.47	.49	.47	.29	.28	.20	.37	NA
TKWD/M	25	.04	.07	.04	NA	.03	.03	.17	NA
	50	.09	.10	.10	NA	.07	.04	.27	NA
	75	.19	.13	.12	NA	.15	.08	.35	NA
POOL/KM	25	24.6	21.4	41.7	24.5	31.5	14.1	48.6	62.4
	50	41.0	28.3	51.0	34.9	44.0	30.9	62.3	71.3
	75	52.7	36.2	68.4	44.9	58.0	44.1	80.0	85.0
POOL SPACE	25	.46	.22	.20	.45	.39	.43	.32	.12
	50	1.84	.57	.37	.62	.81	.83	.50	.16
	75	5.49	4.52	.71	2.22	2.49	2.11	.62	.24
RPD/CBW	25	.039	.035	.066	.048	.057	.042	.069	.068
	50	.045	.042	.075	.056	.066	.065	.081	.076
	75	.060	.046	.098	.076	.077	.076	.091	.107
D50	25	20	20	25	32	53	36	61	113
	50	29	30	49	43	109	53	122	143
	75	50	51	83	143	162	90	132	375
PLNGTH/m	25	.32	.32	.17	.35	.25	.25	.11	.31
	50	.48	.50	.29	.38	.30	.29	.12	.36
	75	.56	.66	.37	.55	.37	.79	.36	.40

Table 2. Data collection methods and equations used to calculate the eight habitat response variables from field surveys. ^a

Habitat response variable	Equation	Data Collection Methods
Width-to-depth ratio (WD) ^b	Bankfull width / mean bankfull depth	Bankfull width Bankfull depth (sum of depths within bankfull divided by n+1)
Total Large Wood pieces / meter (TLWD/M)	Total Pieces / meters surveyed	Total count of large wood pieces >1 m long and 0.1m in diameter. Total length of stream surveyed
Total Key pieces Large Wood/meter (TKWD/M)	Total Key pieces / meters surveyed	Total count of key large wood pieces Key piece size based on average channel bed width of stream surveyed. Total length of stream surveyed
Pool/Km (POOL/KM)	Total number of Pools / meters surveyed * 1000	Total count of pools Total length of stream surveyed
Pool Spacing (PL SPC)	Length of stream surveyed / channel bed width / total number of pools	Total length of stream surveyed Average channel bed width (width of active channel bed from bottom of bank to bottom of bank averaged for the reach) Total number of pools
Residual Pool Depth/Channel Bed width (RPD/CBW) d50	Average of all pool residual depth / average channel bed width Median particle size	Residual Pool depth = maximum pool depth – pool tail depth Average channel bed width Measure intermediate diameter of 100 pebbles
Pool Length/meter (PLNGTH/M)	Total pool length / total length of stream surveyed	Sum of all pool lengths Total length of stream surveyed

a: Table modified from citation by E. Tucker (6/30/05) to reflect the current regional protocol.

b: For a complete explanation of the mean bankfull depth calculation see section 23.13 in the R10 Aquatic management Handbook.

Appendix B

An Example from Traitor' Cove DEIS

Affected environment

Windthrow/ Windfirm Buffers

Forest Plan Standards and Guidelines direct the Forest Service to provide for reasonable assurance of windfirmness to the RMA buffers when harvesting timber units. The risk to buffer integrity due to windthrow can be estimated based on direction of prevailing storm winds, slope aspect, topography, tree species, stand structure and prior evidence of windthrow. Southeast Alaska's damaging winds are from the southeast to southwest direction and are channeled along waterways (Harris, 1989). In the Traitors Cove area, prevailing storm winds are from the south, with areas exposed to West Behm Canal and ridges that funnel wind experiencing stronger winds.

Environmental effects

Windthrow/ Windfirm Buffers

Low degrees of windthrow in RMAs surrounding harvest units may occur in each action alternative. The windthrow is not expected to reduce the integrity of the RMA buffer under any alternative. Wind hazard units have been field identified and a final determination for additional buffers would be made during layout. Few units have exposure to the strongest stormwinds from the southeast due to topography and most high-risk areas are on the mountain slopes where there are few RMA buffers. Francis and SW Neets Analysis Groups are moderately exposed to windthrow risk, while the Rockfish Analysis Group units are generally not exposed to wind hazard.

Forest Service silviculture field crews reviewed all proposed harvest units and rated them for wind hazard based on evidence of past windthrow and exposure to winds from the southeast and West Behm. In most cases, units with wind hazard ratings of moderate or less pose little threat to the integrity of the RMA buffer because they are not exposed to the strongest winds and have only isolated patches of blowdown, damaged trees, or individual trees blown down along forest edges.

Stand examinations identified 15 units with high wind hazard. Of those, ten units have RMA buffers adjacent to portions of the unit boundary. These units are R22, S03, S04, S10, F22, F23, F33, F39, F40, and F45. Additional RMAs that would have a risk to windthrow based on potential wind exposure and topology are units S06 and F34. These twelve units were analyzed for windthrow risk to the buffers (Table Aquatics-5)

The risk to the RMAs, should a unit be harvested, varies on where the opening is in relation to the RMA and prevailing wind direction, and on topography surrounding the exposed RMA. If the opening is on the lee side of the storm winds, the additional risk to windfirmness is minimal because standing trees or hills offer a windbreak to the leeward side (Harris 1989). In areas exposed to West Behm Canal in Francis and SW Neets Analysis Groups, the harvest unit edges on the north and east sides exposed to winds directly from the channel and winds that accelerate around ridges are at risk to windthrow. The following are unit-specific recommendations for potential harvest units (Table Aquatics-3).

Table Aquatics-3
Harvest Units with Identified Windthrow Risk

Source: Raitanen, 2005, Stand Exams

Unit #	Buffer Risk	Stream Class	RMA Location	Risk Factors/Mitigating Factors to RMA	Additional Protection
R22	High	III	North	RMA would be exposed to high winds from the south	Yes
				Ridge effect increases winds	
				No fish habitat in entire stream	
S03	Low	II	West	Glancing wind direction, edge not directly exposed	No
S04	Mod	II	East	Unit exposes RMA to winds from the south and west	Yes
				Near base of ridge, prior evidence of windthrow exists	
				Small hills offer protection from direct winds	
	Low	II, III	West	Leeward side, well protected	No
S06	Mod	II	Northeast	Buffer exposed to West Behm Canal	Yes
S10	Low	III lake	West	On leeward side of windfirm lake buffer, no fish in lake	No
F22	Low	II	West	Leeward side, well protected	No
F23	Low	II	North	Very little RMA exposed, small opening	No
F33	Low	II	West	Leeward side, well protected	No
				RMA in protected valley bottom	
				Soil defer area will add protection to RMA	
F34	Mod	III	North	RMA exposed to south winds, unit is on a ridge	Yes
F39	Low	II	West	RMA in protected valley bottom	No
				Leeward side, well protected	
F40	Low	II	West	Glancing wind direction, edge not directly exposed	No
				Topology wind relief	
F45	Low	II	West	Glancing wind direction, edge not directly exposed	No

Additional protection would be considered and implemented as needed during unit layout for any units with RMAs. Windfirm buffer distances and locations would be applied using unit-specific information such as orientation of prior windfall and exposure to prevailing storm winds. Additional buffers may range from a single row of trees to a distance of one site-potential tree height.

Alternative 2 includes all 12 units shown in Table Aquatics-5; Alternative 3 includes 6 units; Alternative 4 includes 6 units; and Alternative 3 includes 11 units.

Acres of proposed harvest by watershed and alternative are presented in Table Aquatics-7.

Appendix C: Checklist for determining a need for a Reasonable Assurance of Windfirmness Buffer

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Factors to Consider	Present		Description/Notes
	Yes	No	
Indicators of High Risk			
<i>Topographic factors</i>			
Is there evidence of windthrow or windsnap, or pits and mound in the area? Especially along existing clearcut edges or buffer edges on similar topography?			
Is the proposed buffer located near corners of ridges, saddles, or ridgetops?			
Is the proposed buffer located along major bodies of water, especially where water is located to the southeast or southwest of the proposed buffer and the wind has a long fetch?			
Is the proposed buffer located on a convex slope and on southwest to southeast edges of islands?			
Is the proposed buffer located high on a shoulder slope, saddle, or ridgetop?			
Is the proposed buffer located in a major river valley where Bora or Taku winds are known to occur?			
<i>Stand Factors</i>			
Is the proposed buffer located in a wind-regenerated stand, or adjacent to a wind regenerated stand?			
Is windthrow present in the stand?			
Is root rot present and affecting the vigor of the trees? (Consult with silviculturist, Are trees healthy? Chlorotic? Dead branches on portions of the tree?)			
Are the soils shallow to dense till or bedrock? Depth to bedrock or till can often be assessed by visual observations of bedrock or till evident on the sides of V-notches.			
Is there a high degree of canopy closure and small live crown ratios? Is the live crown ration less than 35% and Canopy closure greater than 80 %?			
Are tall hemlock trees present?			
Is it a dense stand of tall trees on wet soil (not common)			

Factors to Consider	Present		
Indicators of High Risk continued	Yes	No	Description/Notes
<i>Buffer Characteristics</i>			
Will the buffer be oriented perpendicular to dominant wind direction?			
Will the buffer consist of tall trees of even-age, that are sheltered by the surrounding stand?			
Is the stream incised less than 25% of the average tree height?			
Is root rot present in the buffer and affecting the vigor of the trees?			
Does the proposed buffer have tall trees on the edges and shorter trees in the middle?			
Does the RMA has very steep sideslopes with very shallow soils and exposed bedrock?			
Will the proposed buffer be adjacent to a large clearcut to the upwind side? (40 acres plus)			
Indicators of low risk	Yes	No	Description/Notes
<i>Topographic factors</i>			
Is the proposed buffer located in a narrow valley bottom with steep valley sides?			
Is there little or no evidence of windthrow on similar topography in the area?			
Is the proposed buffer located on north and northeast facing slopes? Especially if slope is concave?			
Is the proposed buffer is located well inland, in a series of protected valleys well away from areas of long wind fetch?			
Will the proposed buffer be located low on the landscape? (footslope or valley bottom position)			
<i>Stand Factors</i>			
Are the soils deep and well drained and are the trees deeply rooted?			
Is the stand open-grown? Is canopy closure low? Are the trees short with large live crowns?			
Is the bedrock fractured, or is there well developed karst, with evidence of anchoring roots?			

Factors to Consider	Present		Description/Notes
	Yes	No	
Indicators of low risk continued			
<i>Buffer characteristics</i>			
Is the RMA deeply incised? Deeper than 50% of the average tree height?			
Are the trees in the buffer small and open grown?			
Will the buffer will be oriented parallel to the dominant wind?			
Will the proposed buffer be adjacent to a small opening(s) or adjacent to a harvest unit with substantial tree retention.?			
Do the trees in buffer form a crown or hump in the middle? Are shorter trees on the edges of the buffer?			
Does the RMA consist of gentle slopes with little evidence of shallow soils or exposed rock in the RMA?			
Resources-at-risk Factors			
Is the proposed buffer upstream of a public or private drinking water supply, fish hatchery intake or significant karst or cave resource?			
Implementation Factors			
Will the proposed RAW buffer be implementable with the proposed yarding system?			
Will the buffer cause isolation of timber or expensive yarding methods to implement?			
Is the buffer of such high risk that we expect it to blowdown no matter what we do?			

The factors listed in the checklist are listed in order of importance within each category (topographic factors, stand factors, buffer characteristics). Importance is based on whether or not the literature agrees it is an important factor. If the literature did not all agree on the importance of a factor it is listed lower in the checklist. If the literature agrees it is an important factor it is listed high in the checklist (within each category).

In situations where multiple high risk factors are present the risk of windthrow in the buffer is high (Moore, 1977) and some measures should be taken to prevent windthrow (no-harvest, high retention harvest, harvest all, redesign the opening around topography, harvest within the buffer to reduce risk, or apply a RAW zone buffer). In situations where multiple low risk factors are present and high risk factors are minimal, a RAW zone addition to riparian buffers is not warranted.

Where high value resources-at-risk are present, the decision maker may want to use a wider buffer even when the risk of windthrow is moderate.

RAW Buffer design

Once a determination is made that a RAW buffer is needed to maintain riparian and aquatic resources, RAW buffer design should consider natural topographic breaks, vegetation/stand breaks or changes, and logging systems and isolation of timber.

The RAW buffer design must be part of an integrated approach to the desired future conditions of that piece of landscape in which the buffer is situated. In very high risk situations, where the majority of the high risk factors are present, alternatives should be sought to reduce the risk of windthrow. In these cases RAW buffers may be wider than the height of one site-potential tree.