Windthrow Hazard
Assessment and Management Workshop
Notes

Introduction

We are seeing greater use of timber reserves to protect other resources and a trend away from clearcutting toward partial cutting or variable retention systems. As forest management plans become more complex and diverse, the potential effects of wind damage need careful consideration. Understanding and managing windthrow is becoming a more important part of forest management. This workshop will outline the mechanics of windthrow, discuss the physical and biological factors that control windthrow, consider approaches to hazard evaluation and outline a number of strategies for managing windthrow. The windthrow hazard assessment and management approaches discussed in the workshop are being developed and tested across British Columbia.

Workshop outline

- Examples of typical windthrow damage
- Terminology
- Mechanics of windthrow
- Factors affecting windthrow
- Windthrow hazard assessment, classification, risk
- Management strategies
- Monitoring and research approaches
- Case examples (optional)
- Discussion groups (optional)
- Field trip/assessments (optional)

Timeframe is flexible: ≈1/4-1day classroom and 0-1+ day field

Instructor

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Windthrow Hazard Assessment

The purpose of a windthrow hazard assessment is to describe the soil, terrain and forest conditions within a proposed cutblock, to assess the likely effect of timber harvesting on windthrow potential, and to recommend site-specific actions to reduce the likelihood of post-harvesting windthrow based on a qualitative assessment of risk. These actions may involve modification of the cutblock layout, silvicultural system, logging technique, or special treatments (edge feathering, crown pruning) to reduce the likelihood or severity of windthrow.

For additional information on windthrow and windthrow hazard assessment please refer to the Windthrow Handbook for British Columbia Forests (Stathers, Rolleson and Mitchell 1994). In general windthrow hazard assessments use an approach similar to that used for terrain stability field assessments. However, a windthrow hazard assessment should evaluate additional factors relevant to windthrow hazard such as tree and stand characteristics, rooting depth, evidence/history of previous windthrow and apparent direction of damaging winds as determined from existing windthrow. Interpretations for the likelihood or severity and extent of windthrow for a specific area or falling boundary segment use a qualitative windthrow hazard classification based on those factors affecting wind force (or turning moment at the base of a tree) and resistance to overturning. Suggestions for strategies to limit windthrow for both stands and individual trees can be found in the "Windthrow Handbook."

Windthrow prediction can be quite problematic. Investigators who do not have experience with windthrow assessments should work with foresters or others who do, especially in situations where significant adjacent/downstream elements are at risk.

Windthrow hazard assessments can take several forms:

- Preliminary office assessments of existing information.
- Pre-layout field assessment to identify potential windthrow hazards/risks before cutblock boundaries or silvicultural systems have been finalized.
- Post-layout field assessment of cutblocks and proposed silvicultural treatments.
- Assessments of specific sites where the rest of the cutblock has either been assessed previously or does not require assessment.
- Post-logging assessments to refine/modify mitigative treatments to stand/reserve edges and individual trees (e.g., edge feathering, topping).
- To assess prescriptions for salvage/management of windthrown trees.

The level of field effort and the information provided in the report will depend on what type of assessment is being done. A windthrow hazard assessment may be combined with other assessments such as potential surface erosion, potential for sediment delivery to streams, soil degradation, terrain stability, snow avalanche hazards and stream channel stability. Considerable efficiency can be gained by combining more than one type of assessment and teaming with one or more specialists to carry out the work.

Methods of conducting windthrow hazard assessments

The following is intended as a guide to individuals carrying out windthrow hazard assessments. The investigator is expected to exercise his/her individual judgement in selecting the methodology that best suits site conditions, goals of the assignment, and client needs. Only a limited number of the suggestions outlined below need be carried out for any one assessment.

Prior to conducting a windthrow hazard assessment, the investigator should obtain and carefully review all available background information including the following:

- Air photos. These can be a useful part of a windthrow hazard assessment. In some cases investigators will make use of different ages of photography to investigate the windthrow history of an area.
- Topographic maps.
- Forest cover maps.
- Windthrow history/salvage maps (windthrow vector maps).
- Local knowledge of windthrow history (natural and logging related).
- Previous windthrow assessment reports for the area.
- Terrain and/or soils maps; occasionally bedrock maps are useful.
- Gully assessment and terrain stability reports.
- Watershed and/or stream channel assessment reports.
- Stream classification maps or reports.
- Research/monitoring data applicable to the area.

A windthrow hazard assessment tries to assess the potential windthrow hazards of critical or high risk situations within and/or immediately adjacent to the cutblock such as: unstable or potentially unstable areas, steep gully headwalls and sidewalls, stream channels, riparian zones and wildlife habitat and other reserves. As well as ground traverses, helicopter overviews are useful, especially when assessing the extent and general orientation of windthrow.

Traverses along falling boundaries describe and evaluate the soil, terrain and forest conditions inside and immediately outside the falling boundary. For small cutblocks, traverses of the falling boundaries usually suffice. In large cutblocks where partial cutting is planned, additional traverses within the cutblock area are often useful to fully evaluate soil and forest conditions.

The assessment includes potential on-site and off-site effects or consequences of harvesting-induced windthrow.

Traverse all areas of concern. Complex or difficult terrain may require several days of field investigation, especially if partial cutting systems are proposed.

Assess and review critical areas both before and after cutblock layout. Pre-layout assessments will result in more cost-effective layout and windthrow protection. Post-layout reviews ensure that falling boundaries/spatial cutting patterns are optimally designed/located, and avoid potential problem areas. Post-falling assessments can be used to refine or prescribe feathering, pruning and/or topping treatments. Assessments following windthrow events can help improve or refine treatment options in local areas.

Ensure that the assessment is carried out during good weather. Snow cover or bad weather can significantly reduce the quality of the assessment.

Reports

A windthrow hazard assessment report normally includes the following. The order and headings shown are to assist the author but are not meant to establish a rigid template. Flexibility is important. Not all information is relevant for every assessment.

Assignment information

- Client name.
- Site location/name (general geographic location).
- Purpose or objectives of the assessment.
- Type of assessment (pre or post-layout, post-harvest).
- Scope of the assessment. The areas/sections investigated and how the assessment was carried out.
- Type of harvesting system (e.g., aerial, cable, or ground).
- Type of silvicultural system (e.g. clearcut, group retention, shelterwood, etc.).
- Sources of information.

Field assessment description

- Traverse description or traverse map.
- Date of field assessment and time spent in the field.
- Personnel on site during the assessment.
- Cutblock area (ha) assessed.
- Weather conditions at the time of assessment.
- Limiting factors (e.g., snow, weather, heavy groundcover).
- Any areas not traversed, explain why they were not visited.

Background

- General geographic location/setting.

- General terrain and terrain conditions in vicinity of the cutblock
- Windthrow history of the general area relevant to the assessment:
  - natural/logging related windthrow distribution and severity.
  - apparent direction of winds causing windthrow.
  - soil/terrain/stand conditions associated with windthrow locally.

Site information

Site descriptions for in-block logging and adjacent areas should be sufficiently complete, clear and concise to support the conclusions and recommendations of the report:

- Boundary aspect.
- Topographic exposure.
- Boundary orientation relative to direction of locally strong winds.
- Elevation and slope aspect if relevant.
- Soil and/or surficial material types, textures, depths.
- Slope morphology.
- Soil drainage.
- Numerical slope gradients.
- Vegetative indicators of moisture or slope movement.
- Soil creep, seepage, gully/stream channel/bank characteristics, snow avalanche tracks, etc.
- Natural landslide activity (presence or absence):
  - distribution, magnitude and effects.
  - initiation zones, runout zones, deposition zones.
- Wildfire history (vets tend to be windfirm).
- Rooting depths.
- Stand/tree characteristics (density/structure).
- Windthrow (natural and logging related):
  - orientation.
  - frequency (severity) and extent.
  - typical rooting depths/soils/terrain etc. associated with windthrow.
  - pit and mound micro topography

Conclusions

The conclusions should be clearly stated in plain language so that forest workers fully understand the planning/management implications:

- Expected outcomes of logging given by segments/areas along the falling boundary, reserve areas, interior of the cutblock:
  - likelihood or expected severity and extent of windthrow.
  - will windthrow jeopardize adjacent areas?

- likelihood of windthrow progressing into unstable or potentially unstable areas, gullies, riparian zones immediately adjacent to stream edges.
    - likelihood of surface erosion/sedimentation.
    - other elements at risk.
- Mitigation opportunities/alternatives for controlling windthrow:
    - Relocation or reorientation of boundary to more windfirm locations/conditions.
    - Feathering (removal of vulnerable stems).
    - Crown modification opportunities (topping and pruning).
    - Falling to waste or for later salvage.
- Adjacent or downstream elements at risk and possible consequences.
- Safety concerns – situations where specific windthrow mitigation treatments or salvage of windthrow could present an undue risk to workers.

The conclusions should include a rationale:

- Past response to strong winds of comparable natural or logged areas nearby.
- Local knowledge/history.
- Applicable research data/knowledge where available.
- Other rationales.

Recommendations

The recommendations should be clearly written so that everyone understands what needs to be done:

- Given by clearly defined segments/areas along the falling boundary, reserve areas or interior of the cutblock:
    - Logging issues, e.g., falling boundary/reserve relocation, alternative logging methods, modification to silvicultural treatments (e.g. changes to group or dispersed retention patterns, edge feathering).
    - Crown modification treatments.
- Additional investigations or other expertise where applicable, e.g., terrain stability assessments, stream channel/riparian, snow avalanche assessments.
- The investigator's rationale for recommendations should be outlined.

Methods of describing cutblocks and adjacent areas

- linear by falling boundary sections (delineated by falling corners or other geographic references), supplemented with map polygons, points, groups of points or spatial descriptions as necessary to clearly describe the interior of the block or adjacent areas. This is the usual approach.
- map units (polygons) with detailed site descriptions for each unit or stata delineated may be quite useful for windthrow hazard assessments of partial cutting areas. Linear traverse notes that clearly document the extent of field

investigation carried out to define the polygons should accompany map unit descriptions. The use of map unit descriptions does not excuse the investigator from carrying out full and complete foot traverses of all critical areas within and adjacent to the block. Descriptions based on single point observations or incomplete traverses of critical areas are questionable, especially if the area is highly variable. The investigator needs to ensure that map unit boundaries and descriptions are accurate and do not mislead the reader as to the extent, variability or character of the terrain, soils and forest stands included in each polygon.

Investigators should use accepted standard terminology in windthrow hazard assessment reports to the extent possible to avoid confusion or misinterpretation of reports. The following are the conventions in common use for this type of work in the forest sector in BC. If the author is not using the following conventions he/she should state which convention he/she is using.

- Forest soils—Canadian System of Soil Classification.
- Terrain and surficial materials—Terrain Classification System for British Columbia (1997).
- Gully/stream descriptions—Gully Assessment Procedure Guidebook.
- Stream descriptions—definitions given in the Channel Assessment Procedure Guidebook and the Riparian Management Area Guidebook.
- Windthrow Handbook for British Columbia Forests (1994)

Maps generated by the investigator should use generally accepted cartographic conventions. For example, see those specified by the Terrain Classification System for British Columbia (1997) and the Guidelines and Standards for Terrain Mapping in British Columbia (1995) to indicate map reliability.

Appendices and attachments

Presentation of information will depend to some extent on the specific requirements of the client and the manner in which the windthrow hazard assessment report is submitted. For example, if the windthrow hazard assessment report is attached to logging plan documents, other relevant information may be in the logging plan (e.g., stream classifications, terrain classification/stability mapping, 1:20,000 location maps, etc.). If the windthrow hazard assessment is a stand-alone document, or is being forwarded for review or other information purposes, it may be helpful to attach some of these other documents or relevant information from them.

A client's standard operating procedures may require windthrow hazard information to be presented in a certain format. The investigator must have the flexibility to address these requirements.

Typical attachments include the following:

- 1:5 000/1:10 000 map(s) showing topography, obvious forest features, setting boundaries and road locations, traverse routes, windthrow hazard areas, critical terrain features.
- Additional sketch maps/diagrams may be useful to delineate relatively homogenous areas/segments of the cutblock, identify specific windthrow hazards, or to illustrate recommendations.
- 1:20 000 (or in some cases 1:50 000) location map of cutblock and/or roads.
- Photos where feasible and useful.
- Summaries of gully assessment data or stream descriptions/classifications, where relevant.

Limitations of windthrow hazard assessments

A windthrow hazard assessment depends on visual observations of stand conditions, surface terrain features, soil pits and natural exposures encountered during the field visit, supplemented by air photo interpretation and evaluation of topographic maps and other information as available. Wind patterns and wind forces as affected by topography, stand characteristics and silvicultural treatments are very difficult to predict. It is, by nature, a qualitative assessment based on the investigator's training, observational skills and experience in similar terrain and forests. Prediction of windthrow hazard is based upon an understanding of past and present processes and the extent to which they are influenced by forestry operations. Windthrow hazard predictions will likely be more accurate for some areas than for others. One of the best ways to improve the accuracy of hazard assessments is to monitor the windthrow response of different forest stands to varying silvicultural treatments and to document the local conditions controlling windthrow.

Recording windthrow orientations

Windthrow hazard assessments and interpretations are based on field observations of terrain, soils, tree and/or stand characteristics and natural windthrow orientations. Figure 1 shows an example of the orientations of windthrown trees observed during traverses along road and falling boundary locations. The selected nature of these traverses may introduce some unknown amount of bias into the data set. The recorded orientation of a windthrown tree is the direction towards the top of the tree. Do not record orientations of windthrown trees on steep rocky slopes because down slope movement of the tree (falling and/or sliding) may influence the final tree orientation. Similarly, orientations are not recorded for windthrown trees that were growing on nurse logs or on steeply inclined surfaces that may have exerted some control over the direction of fall of the windthrown tree. Do not record orientations for fallen trees that do not have an attached root mass. If there are a great number of windthrown trees in an area then only record the orientations of the more recent windthrow. Record both the orientations of the windthrown trees and the boundary segment (e.g. Falling corner 15 to 21) or road station range where the windthrown trees are located. Between 75 and 100 orientations usually give reasonable results. Consider recording tree species as there can sometimes be differences in the orientations of different species. You can use the histogram routine in Excel to generate plots or import into your favorite statistical package to determine the dominant windthrow directions in a local area.

Figure 1 - A12 Windthrow Orientations

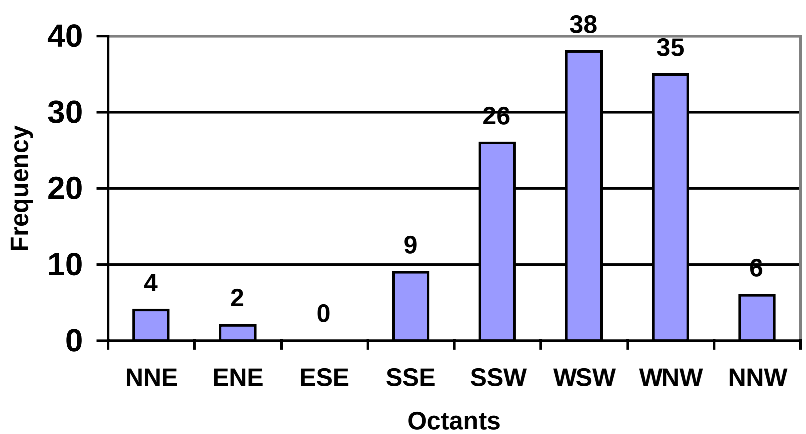

Figure 2. Wind Exposure Index

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Boundary Exposure 1		Boundary Exposure 2: Lee	Lee Diagonal	Parallel	Windward Diagonal	Windward
		1	2	3	4	5
Lee	1		3	4	5	6
Lee Diagonal	2	3	4	5	6	7
Parallel	3	4	5	6	7	8
Windward Diagonal	4	5	6	7	8	9
Windward	5	6	7	8	9	

Note: Wind Exposure Index = (Boundary Exposure 1 rank) + (Boundary Exposure 2 rank)

Wind Exposure Index Rank:

- 3 = very low
- 4 = low
- 5 – 7 = moderate
- 8 = high
- 9 = very high

The wind exposure index (WEI) is a simple, qualitative scoring scheme, developed for a riparian windthrow study on Northern Vancouver Island, that ranks the expectation that a specific falling boundary segment will be affected by strong winds from more than one direction. The primary and secondary (or co-dominant) windthrow orientations for a block are compared in turn to each specific boundary segment orientation (aspect) to determine the primary and secondary exposure categories for that boundary segment (i.e., lee, windward or an intermediate exposure category). The assumption is made that the post-logging windthrow orientations in a sample block or boundaries in the immediate vicinity indicate the dominant wind directions that may affect a specific boundary segment. A simple ranking matrix is then created that lists boundary exposure categories along the x and y axes, defined as lee through windward and ranks them consecutively (i.e., lee = 1, parallel = 3, windward = 5). The individual rank values are added vertically and horizontally to determine the WEI for specific boundary segments or riparian strips. When there is only one windthrow (wind) orientation the WEI can be less than 3.

Figure 3. Qualitative Windthrow Hazard Ranking (*likelihood of windthrow*)

Overturning Hazard \ **Wind Force Hazard**	**L**	M	H	
L	**L**	**LM**	**M**	**Windthrow Hazard Ranking**
M	**LM**	**M**	**H**	
H	**M**	**H**	**VH**	

Overriding Hazard Indicators		L	M	H	VH

If the interaction of wind force hazard and overturning hazard[1] is less than that indicated by the overriding hazard indicator *(for example, existing natural windthrow or windthrow in or along similar areas logged nearby)*, the overriding hazard indicator is used to rank the windthrow hazard.

Figure 4. Qualitative Windthrow Risk Ranking (*risk = hazard x consequence*)

Consequence \ **Windthrow Hazard**	L	M	H	VH	
L	L	**L**	**LM**	**M**	**Windthrow Risk Ranking**
M	**L**	**M**	**MH**	**H**	
H	**LM**	**MH**	**H**	**VH**	
VH	**M**	**H**	**VH**	**VH**	

Qualitative Consequence Ranking can take the form of the following example:

L = forest loss/damage, minor erosion
M = damage to non-fish streams, gully sidewalls, wildlife habitat
H = damage to fish streams, water quality, large landslides
VH = safety/life

Risk ranking can assist in the allocation of hazard mitigation treatments. For example, the amount of crown pruning of individual trees can vary with apparent risk: low risk—no pruning, moderate risk—spiral pruning of 20-30 % of the crown, high to very high risk—spiral pruning of 40-50 % of the crown

[1] R.J. Stathers, T.P. Rollerson and S.J. Mitchell. Windthrow Handbook for British Columbia Forests. 1994. B.C. Ministry of Forests., Victoria, B.C. Working Paper 9401.

Terrain/Windthrow Field Assessment : Block:_______________ Page___of___

Observations						
Falling corner range						
Stations (m)						
Terrain						
Slope position						
Slope morphology						
Slope curvature						
Soils						
Seepage						
Aspect (°)						
Elevation (m)						
Slope us %						
Slope ds %						
Bedrock						
Bedrock structure						
ABD						
Stability						
Rooting depth ~						
Stand structure						
Stand height (m) ~						
Forest cover type						
Windthrow (°)						
Photos:						

Observations						
FC's or stations (m)						
Stream #/name						
Stream class						
Stream width (m)						
Stream depth (m)						
Bank/bed material						
Gully/Stream ∠%						
Gully depth (m)						
Gully floor width						
Gully wall ∠ %						
Terrain						
Photos:						

Comments / photos diagrams / options*	

** describe treatments that may reduce windthrow along specific boundary segments.*

Assessments: Windthrow € Stream channels/riparian € Terrain stability € Gullies €

Personnel:

Weather: Silvicultural system:

Watershed: Harvesting system:

Recorded by: ________________________________ Date: ___________________________

Variable Retention - DRAFT Definitions[2]

Variable Retention

An approach to silvicultural systems and logging in which structural elements of the existing stand are retained throughout a harvested area for at least the next rotation to achieve specific management objectives. The approach utilizes a wide spectrum of retention with varying amounts, types and spatial patterns of living and dead trees. The **"retention silvicultural system**", as defined below, is the primary system used for implementing variable retention. It has two variants: group (aggregated) retention and dispersed retention. The two variants may be used in the same cutblock. Variable retention can be combined with conventional silvicultural systems to define the cutting and regeneration strategy (e.g. uniform shelterwood with group retention; group selection with dispersed retention). It can be implemented with specific criteria, depending upon the management objectives, forest-level practices and ecological characteristics of a landscape unit.

Retention silvicultural system

(proposed new definition under the BC Forest Practices Code)

A silvicultural system that retains structural elements from the pre-harvest stand, such as live and dead trees and woody debris, for at least one rotation, to provide structural diversity and forest or residual tree influences over the majority of a cutblock.

Forest influence

The biophysical effects of forests or individual trees on the environment of the surrounding land. The degree, type and distance of influence can vary widely. Within and adjacent to harvested areas, most forest edge and residual tree influences begin to diminish significantly at distances greater than one tree length from a standing tree, group of trees or forest edge.

[2] From Bill Beese, Forest Ecologist, Weyerhaeuser Canada Ltd. 65 Front Street, Nanaimo, BC. V9R 5H9