

Your *TREE* Fund Donations at Work

PREDICTION OF TREE FAILURE DUE TO WIND LOADING

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WINDCALC is a quantitative tool for assessing and understanding the mechanical forces associated with windthrow. The objective is to provide arborists with a simple and accessible means to estimate crown loading and resistance for the assessment of tree hazards. WINDCALC has been programmed using forms and Visual Basic for Applications in Excel and is designed to run on any computer with the MS Office suite of programs. The equations used in WINDCALC are based on the loading and resistance functions used to calculate stand damaging wind speeds in ForestGALES, which was developed by the UK Forestry Commission to calculate risk in even-aged conifer plantations. WINDCALC is therefore most relevant for the assessment of healthy conifers to be retained in green belts or in newly cleared subdivisions. It is important to note that the underlying equations that calculate wind loading and resistance are based on empirical relationships from wind tunnel and tree winching experiments with healthy trees, and that these regressions have error terms associated with them. The model upon which WINDCALC is based, ForestGALES_BC, has been adjusted using winching and wind tunnel results for four BC conifers, but has not yet been validated using field observations of wind damage. Therefore, this tool must be used in conjunction with professional judgment when assessing the risk of windthrow at a particular location.

Applications and Limitations

WINDCALC is designed as an instructional tool to help arborists understand wind loading and resistance of healthy trees and how that changes with pruning or topping treatments. WINDCALC is based on empirical functions to estimate loading and resistance, which have associated sampling error. Therefore, the actual values representing applied force, moment and safety factor

will range above and below the calculated values. For example, a safety factor of 1.32 is an average predicted value based on the ratio of the predicted load and resistance of a tree at a specified wind speed. The errors associated with the loading and resistance functions will cause the actual safety factor to range above and below the predicted value. Therefore, this output requires additional interpretation from prac-

tioners based on their experience and risk tolerance. Typical engineering safety factors are based on loads, which are three times the breaking strength of materials in much less variable conditions. Therefore, users of WINDCALC must be aware of these factors when evaluating the outputs. The final version of WINDCALC will have pop-up comments associated with relevant fields to explain their intended use and interpretation.

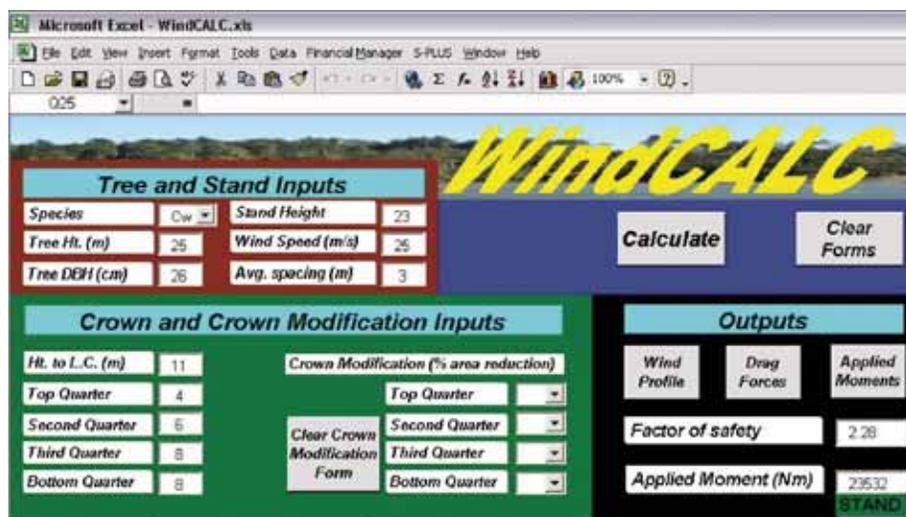


Figure 1. WINDCALC interface displays input and output fields and functions.

Current Status of WINDCALC

Figure 1 shows the current state of development for WINDCALC V.1, which has now been programmed to calculate tree loading according to tree, stand and meteorological conditions as input by the user for four conifer species. Fields and drop-down menus are also available for the user to directly enter crown characteristics and crown modification options.

Figure 2 shows the tree and stand inputs available to the user. These inputs are easily measured characteristics (e.g. species, tree height and DBH, inter-tree spacing, etc.) or obtained (e.g. peak mean wind speeds from local knowledge or online at

<http://climate.weatheroffice.ec.gc.ca/index.html>) and focus on key variables related to windthrow. Currently, the species options include western red cedar (Cw), western hemlock (Hw), lodgepole pine (Pl), and hybrid spruce (Sx). With the basic functions now operational, work is underway to add parameters for black spruce, jack pine, black cottonwood, paper birch, red alder and big leaf maple.



Tree and Stand Inputs			
Species	Cw	Stand Height	23
Tree Ht. (m)	Cw	Wind Speed (m/s)	25
Tree DBH (cm)	Hw	spacing (m)	3
	Pl		
	Sx		

Figure 2. Tree and stand input options.

Crown characteristics are entered as shown in Figure 3. The first entry (Ht. to L.C.) is the ratio of height to live crown. The next four entries allow the user to customize the crown shape based on estimates or measurements of the width in each quarter length of the crown. There is also a capacity to modify the crown to analyze the effect of pruning or topping on the wind loading of the tree.

Crown and Crown Modification Inputs			
Ht. to L.C. (m)	1.1	Crown Modification (% area reduction)	
First Quarter	0.1	First Quarter	
Second Quarter	0.1	Second Quarter	
Third Quarter	0.1	Third Quarter	
Fourth Quarter	0.1	Fourth Quarter	
		Clear Crown Modification Form	

Figure 3. Input fields to customize crown shape and crown modification.

Once all the input fields are complete, the simulation is run using the “Calculate” button and a summary of outputs are produced as shown in Figure 4. The total applied moment is the sum of all the products of force and height

of force. The factor of safety is the ratio of critical resistive moment and the total applied moment. The critical resistive moment in its current form works behind the interface and is based on regressions calculated from tree winching experiments on these four conifer species. Work is underway to include the breaking resistance of the conifer and deciduous species based on published models of rupture values and tree dimensions. This will enable a prediction on whether the tree will break or uproot. Since tree winching data is not available for deciduous species, the resistive moment will be solely based on the critical resistive breaking moment at breast height. Parameters will also be added to the resistive breaking moment to adjust it for defects and decay.

Calculate		Clear Forms	
Outputs			
Wind Profile	Drag Forces	Applied Moments	
Factor of safety		2.28	
Applied Moment (Nm)		23532	
STAND			

Figure 4. WINDCALC output display.



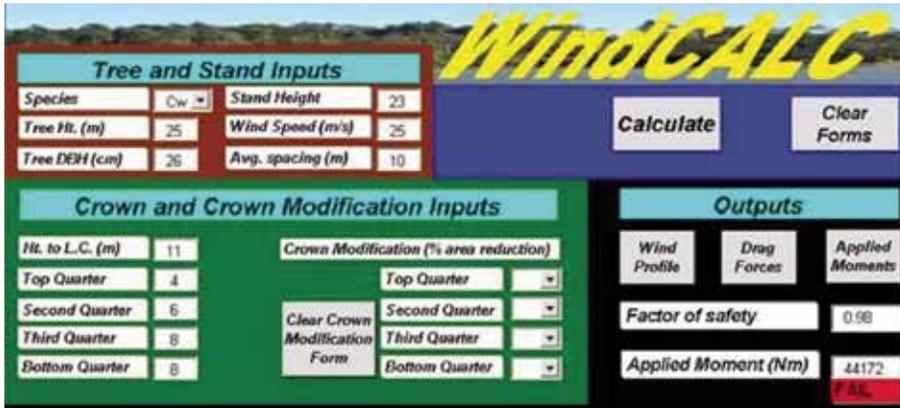


Figure 5. Simulation of western red cedar with no crown modifications

“Work is underway to include the breaking resistance of conifer and deciduous species based on published models of **rupture values and tree dimensions**. This will enable a prediction on whether the tree will break or uproot.”

To enable practitioners to see the effects of modifying input values, there are several graphical outputs. Figure 4 also has buttons to activate graphic representation of the vertical wind profile

Figure 5 demonstrates how a crown modification in WINDCALC changes the crown loading and consequently the safety factor. This allows the practitioner to simulate the effects of different treatment scenarios and to analyze the resulting wind profile, drag forces and applied moments. It is also possible to simulate the effects of different wind speeds.

Promotion of WINDCALC and Windthrow Workshop

Ken Byrne presented the latest work on ForestGALES_BC and WINDFIRM on August 9, 2007 at the IUFRO International Conference on Wind and Trees (August 5-9, 2007) in Vancouver, BC. Forest-GALES_BC contains the foundation theory upon which WINDCALC is based. This presentation was one of three on the status of windthrow models and was followed by a panel discussion to facilitate comments and questions for the presenters from the audience, which in-

cluded 100 international researchers and 15 attendees from the local urban forestry community.

An in-house download session was scheduled for January 16, 2008 at the British Columbia Institute of Technology (BCIT) to demonstrate the function and application of WINDCALC. Faculty, students and local urban foresters were invited to this session, which was in seminar format, to view, use and suggest any additions to WINDCALC before it is presented in its final form to arborists at a windthrow workshop. This workshop is scheduled for the end of February 2008 at the BCIT Woodlot in Mission, British Columbia, and will focus on the mechanics of windthrow, principles of windthrow monitoring and prediction, and provide a demonstration of the use of ForestGALES and WINDCALC in a forested setting near a major urban centre.

An application will be submitted to the International Society of Arboriculture to have this workshop approved for ISA continuing education credits for urban forest professionals. ♦

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