ECOLOGICAL SOLUTIONS INC.

INTRODUCING A NEW VM TOOL

OPTIMAL CLEAR WIDTH CALCULATOR

Determine optimal clear widths for varying canopy and line heights.

Optimal Clear Width Calculator

- Available on an annual subscription basis

Economy through Ecology

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What is the Right Clear Distance?

Is there such a thing? It's not a new question in our industry. In fact, John Goodfellow started a presentation at the annual ISA conference in Halifax in 1994 with that question. It stuck with me. Eventually the method to determine the answer emerged.

When the calculations were complete and I graphed the result, it was apparent there is indeed a right clear distance - based on the amount of risk you're willing to tolerate.

Who Can Benefit from the *Optimal Clear Width Calculator*?

Your utility if:

- Lines running adjacent to natural tree stands are a major source of service interruptions
- Tree or branch failure account for the majority of your tree-caused outages
- Trees on the ROW are controlled

And, benefits increase if:

- You have a lot of rural lines
- Lines running through forests
- You are adding, moving or upgrading lines
- Government forestry staff are limiting the right of way width
- Your company is seeking to make major reductions in tree-related outages
- Your utility has to report reliability statistics to the PUC
- The PUC imposes penalties for inadequate reliability
- Your PUC is discussing reliability standards and reporting
- The PUC is limiting the right of way width while asking you to reduce tree-related outages
- Municipal governments are restricting clear width

What's the Significance?

Would it be meaningful if you had a quantitative means of reducing the risk of tree-conductor contacts? If you answered yes, I want to show you

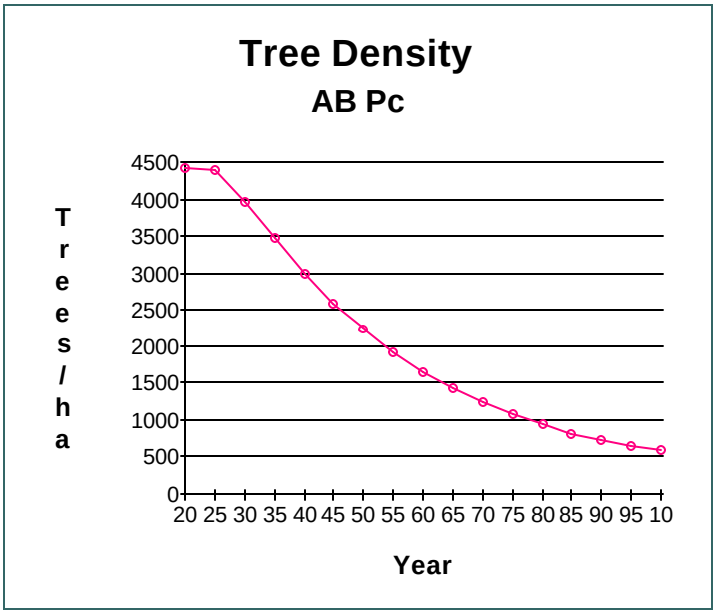
how and where it's possible to use the ***Optimal Clear Width Calculator*** to make substantial improvements in reliability. What kind of improvements am I talking about?

... 30% to 70% reductions in tree-caused outages for distribution lines when focusing efforts on problem areas

Of course, the actual improvement will depend on local tree and operating conditions and to what extent tree-conductor contacts are concentrated to specific portions of the system.

Ecological Framework

This opportunity for a substantial reduction in tree-caused outages arises from the fact that nature overstocks young forests. As the trees grow and compete for light, water and nutrients, the majority of the tree population dies off. The Tree Density chart below shows a greater than 90% reduction in tree density over time for lodgepole pine in Alberta . To get a sense of the number of trees posing a risk to power lines, picture the Tree Density chart inverted from top to bottom. While the number of decadent trees will vary for forests of different species, the trend will be the same. And the trend applies to both even-age and uneven-age stands.



Translating the Tree Density chart into a utility context, it indicates that in a one mile strip 20 feet wide (equals 1 ha) there will be about 3500 dead or dying trees capable of striking the line over a 70 year period. That's an average of 50 trees per mile per year in just the first 20 feet. Factoring in the height of trees it would be appropriate to consider 60 feet of the stand. There are then 150 trees per mile per year dying. Admittedly that is the high end but based on the lowest tree mortality rates my research revealed, the low end is 21 trees per mile per year. The low end data comes from old growth forests, which comprise only 6% of U.S. forests.

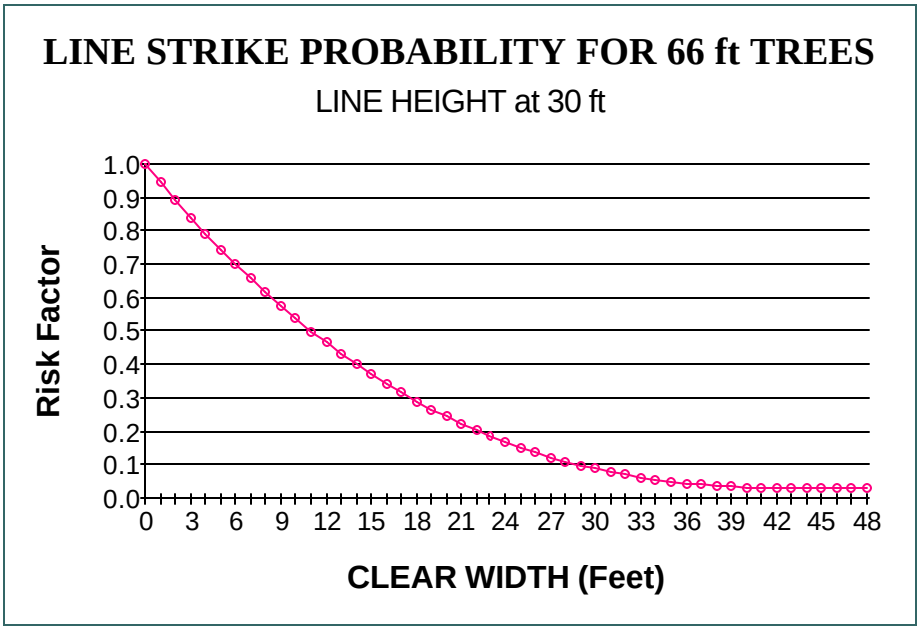
Annual tree mortality rates range from 0.5% to 3% of the existing stand. Using a tree density of 250 trees per acre for 85 foot trees, that's 1818 trees/60 ft. mi. Annual mortality is 9 to 55 trees per mile of right of way side depending on the local mortality rate. Compare that to the number of trees you remove per mile per year as hazard trees. Chances are that tree mortality dwarfs your hazard tree removal rate by one or two orders of magnitude.

Managing the Liability

Tree mortality and the fact that even healthy trees fail in severe weather shows trees to be a liability to an overhead electric system. The primary source of risk for lines in forested areas is simply tree exposure, the number of trees within striking distance of the line. Based on that understanding, I've developed an approach to quantifying the tree risk - the ***Optimal Clear Width Calculator***, which produces the ***Line Strike Probability Chart***.

A sample ***Line Strike Probability Chart*** is presented on the next page. Examining this chart it is evident that there is a point of diminishing return in line security for the dollar invested in clear width. In this example, a clear width of 22 feet would reduce the risk of trees striking the line to 0.2 or by 80%. At that clear width only 20% remains as residual risk to be managed through the hazard tree program.

For the conditions assumed in this example, increasing the clear width from 10 feet to 22 feet reduces tree-caused service interruptions 64%. And because increasing the clear width reduces the extent of tree exposure, that reliability improvement will apply to both normal operating conditions and severe weather events.



The inputs required to produce the ***Line Strike Probability Chart*** are tree height, line height, and tree density. The Risk Factor on the Y axis of the ***Line Strike Probability Chart*** is not a stand alone probability. Rather it is a measure of the tree exposure for a section of line. The Risk Factor can only be used in comparing options, usually on a specific line segment. ***Line Strike Probability Charts*** can also be produced to examine the impact of increasing conductor height as this also reduces the extent of tree exposure.

Where Does the Quantified Risk Reduction Apply?

Since I'm using characteristics of natural tree stands to develop the ***Line Strike Probability Chart*** it applies to situations where lines run through or adjacent to natural tree stands. It is not suitable for single trees or single rows of trees.

Who Cannot Benefit?

Utilities serving only urban areas where the trees encountered are almost exclusively planted landscape and boulevard trees will have limited opportunity to apply and benefit from the risk reduction information provided by the ***Line Strike Probability Chart*****.**

Right of Way Width

What I'm proposing is to consider adjusting the right of way width or more specifically the clear width (horizontal distance from line to base of trees) for a quantitative risk reduction. The ***Optimal Clear Width Calculator*** makes it easy to determine the tree exposure or risk for different clear widths and to determine the cost of tree work to achieve a specific residual tree risk. Knowing the cost and line security benefit of adjusting the clear width, your company can then compare the cost/benefit of other options such as increasing conductor height, installing coated conductors, under-grounding, etc. before choosing the method that provides the greatest security per dollar.

But why consider adjusting the right of way? Perhaps you classify outages caused by trees beyond the right of way edge as non-preventable... they're not your problem. Customers, however, are equally inconvenienced by these outages. Given the ever increasing demand for reliable electric service, at some point you may be asked to reduce what are currently classified as non-preventable outages. Over the last few years regulators appear increasingly intolerant of widespread outages during severe storms. In other words, they're moving to hold you accountable for all outages regardless of their origin.

Certainly there are barriers to adjusting the right of way width. Forestry staff, for example, are guided by policies for resource preservation. However, a ***Line Strike Probability Chart*** will allow you to quantitatively demonstrate the increased safety and reliability for a desired clear width. If your efforts to increase the safety of the system are refused, it may still be beneficial to your company by transferring some of the liability risk.

The cost of increasing the clear width may be a barrier. The ***Line Strike Probability Chart***, however, brings a new, clearer focus to the risk reduction benefit thereby improving the cost/benefit analysis process. This serves to bring utility vegetation management into what was previously exclusively an engineering domain and thereby elevates the profile and significance of vegetation management within the company. It gets VM into the game.

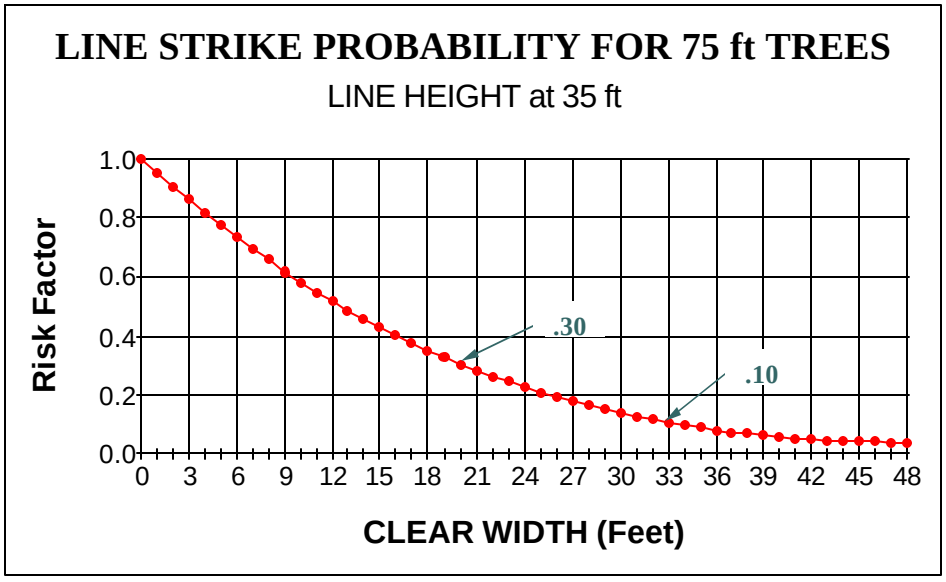
An Example

To illustrate the use of the quantitative approach to tree risk assessment provided by the ***Optimal Clear Width Calculator*** let's take a simple example.

Tree-caused outages are a major irritation on 34.5 kV sub-transmission. There are 34 tree-caused outages per year per 1000 miles of line due to tree failures. You have been asked to explore the options available to reduce tree-caused outages. In the past you've redoubled your hazard tree identification efforts by decreasing the cycle from 5 years to 3 years, removing 10 trees per mile of treed right of way edge. While this effort has shown a measurable 30% improvement in reliability for the year following the hazard tree program, the improvement persists only for one year. The hazard tree program is not providing a base for continuous improvement. You wonder if increasing the right of way width is the answer. What impact would increasing right of width from 50 feet to 75 feet have on reliability?

Construction is wood poles with 10 foot cross arms set in a 50 foot right of way. Typical conductor height is 35 feet. Tree height is 75 feet and tree density is 250 trees per acre.

The current clear width can be calculated as (50 foot ROW - 10 foot cross arm)/2 = 20 feet. Increasing the right of way width to 75 feet would result in (75 foot ROW - 10 foot cross arm)/2 = 33 foot clear width.



Entering information into the ***Optimal Clear Width Calculator*** yields the adjacent ***Line Strike Probability Chart***. The Risk Factor at the current clear width of 20 feet is .30 and at 33 feet it is .10.

Using a simple spreadsheet allows a quick assessment of the line security improvement and provides a means of calculating the cost of additional clearing.

The spreadsheet shows that increasing the right of way width to 75 feet will result in a 67% reliability improvement. Tree-caused incidents can be expected to decrease from 34 per 1000 miles to 11 per 1000 miles. Because the hazard tree program would be applied to a reduced residual tree exposure, its impact will be more significant. Unit costs can be entered permitting a calculation of the $/% reliability improvement. Not only does the ***Optimum Clear Width Calculator*** allow you determine the reliability improvement in advance of doing the work but by adding cost data, permits a comparison of value with other options such as underground, altered construction, etc.

Cost: Benefit Analysis

Line Segment Specific:		Ac/mi	Trees/mi	Cost/mi	Line Security Improvement
Line Height	35				
Tree Height	75				
Trees/Ac	250				
Current Clear Width	20				
Current Risk Factor	0.3				
Increase Width	13	1.58	394		
New Risk Factor	0.1				67%
Removal Cost/tree *	$8			$3,152	
Removal Cost/tree **	$60			$23,636	
* Using feller buncher					
** Chainsaw removals					

How to Benefit

Emerging information on tree-related outages indicates that tree failure typically accounts for about 85% of all tree-caused outages. If you've had a reasonable amount of funding and followed IVM practices, the right of way floor area is managed. Perhaps you can demonstrate progressive reliability improvements. But if you want to continue these progressive improvements, you will need to look outside the right of way. And while a hazard tree program is a definite necessity, unless you're willing to launch a hazard tree program that is one to two orders of magnitude more aggressive than typical utility hazard tree programs, it will be dwarfed by natural tree mortality and fail to provide enduring reliability gains. When it's time to look beyond the right of way edge, you'll need to justify actions with clearly articulated benefits. The ***Optimal Clear Width Calculator*** and its product the ***Line Strike Probability Chart*** are the tools that will help you do so.

Utilities facing scrutiny or worse, penalties from the PUC will want to identify opportunities for improving reliability. If you were impacted by reduced maintenance funding as your company sought to lower costs in preparation for competitive markets, your tree trimming program may be behind and offer opportunities for reliability improvements. But if vegetation management funding has been increased to correct the problems that emerged, then at some point there will be no more gains available from within the right of way. How do you continue to build on the improving reliability you've delivered? By decreasing the amount of tree exposure. Adjusting the clear width is one way. The size of the opportunity will be determined by the amount of line running adjacent to natural tree stands and the ratio of tree-caused outages to total outages. And decreasing the amount of tree exposure has line security benefits in both normal operating conditions and severe weather.

Where clear distance is restricted by outside authorities or the public, the ***Line Strike Probability Chart*** can be used as an education and persuasion tool. If the outside agency refuses to allow the utility to quantitatively reduce safety, fire and reliability risks, do they not make themselves liable for the consequences of their decisions?

The Benefits of Using Tree Risk Assessments

As you use this quantitative approach to managing tree risk you will find it provides:

- A means for progressive reliability improvements
- Another method of assessing the role of trees on circuits experiencing poor reliability
- A means of setting specific, acceptable, residual tree risk levels
- A basis for prioritizing investment to maximize reliability gains and minimize losses
- A means of rationalizing capital investment in equipment or methodologies that prevent tree-caused outages
- A means of illustrating to regulators the need for and prudence of line clearance maintenance decisions and funding

What Are These Benefits Worth?

What is increased safety worth? What is the value of avoided storm damage or possible regulatory hearings. What about transferred liability? What are the customer satisfaction implications of superior reliability?

Well, the ***Optimum Clear Width Calculator*** and ***Line Strike Probability Charts*** are available to you for a small fraction of the value of the benefits.

How to Get the *Optimal Clear Width Calculator* and *Line Strike Probability Charts*

If you want to run "what if" scenarios to examine various forest canopy heights or to compare whether changes in pole height or increased right of way width will yield the most cost effective risk reduction, you will want to subscribe to the ***Optimal Clear Width Calculator***. It is an Excel spreadsheet. You can order through any of the contact channels on the first page or you can download the order form at www.ecosync.com. Annual subscription prices are $1,000 US for an individual subscription (some restrictions apply), $1,500 for a corporate subscription and $2,500 for an Enterprise subscription.

Want to get the most value out of the ***Optimal Clear Width Calculator*** right away? Arrange a training workshop. In consultation with you, I'll structure the workshop using examples that are specific to your area. You will also receive written documentation of the examples used in the training workshop.

What the Research Shows

Since the introduction of the ***Optimal Clear Width Calculator***, Ecological Solutions Inc. has been involved in a number of projects seeking to understand the primary, controllable drivers of tree-caused outages. While line height, tree height, clear width and tree density are all factors having a bearing on tree risk and reliability, none of them were found to be significantly correlated to the tree-related interruption experience. In fact, only two tested variables have emerged as being significantly correlated to the outage experience—they are danger trees per mile of right of way edge and the Risk Factor rating produced by the ***Optimal Clear Width Calculator***.

What does this mean? The primary driver of tree-related interruptions is the extent of tree exposure the power lines face. And the strength of the correlations, with r values in the 0.9 range, informs us that achieving major reductions in tree-related outages will necessitate reductions in tree exposure.

Managing Tree-related Interruptions

Reducing tree exposure to zero would involve putting the lines underground or clearing enough right of way to convert the lines to tree free. Typically, neither of these are viable options. Consequently, utilities are left with the need to manage tree-related interruptions in the context of having to tolerate some side tree exposure. But how much tree exposure can be tolerated while also meeting customer and regulator reliability expectations?

The ***Optimal Clear Width Calculator*** is a tool that will translate changes in tree exposure into outage expectations. Such quantification opens the door to other possibilities. For example, because reductions in tree exposure will reduce outages during major storms, financial models optimizing reliability benefits for avoided restoration costs can be developed.

I'd be happy to discuss the uses of the ***Optimal Clear Width Calculator*** with you.

If you have lines or are adding lines that run through or adjacent to natural tree stands the ***Optimal Clear Width Calculator*** will become an invaluable VM tool. Ecological Solutions Inc. would like to be of service in quantifying the risk of tree-conductor contacts but only you can start the flow of benefits. I look forward to hearing from you.

Yours truly,

Sig Guggenmoos

P.S. Reducing the extent of tree exposure whether through widening the right of way or increasing line height reduces the reliability and safety risks for the long term, in good weather or bad. On capital projects you can use the ***Optimal Clear Width Calculator*** to demonstrate that increasing the clear width increases the asset value.

P.S.S. For more examples of applications of the ***Optimal Clear Width Calculator*** go to the web page http://www.ecosync.com and follow the Vegetation Management link.