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Managing Trees to Improve the Bottom Line

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As regulators increasingly scrutinize reliability of electric service, storm response and mandate reliability targets, trees emerge as a major risk to utilities. Understanding the drivers of tree liability opens the door to managing tree risk and simultaneously minimizing tree-related outages and maintenance costs.

Context for Tree-Conductor Contacts and Service Interruptions

In a 1995 R.J. Rudden Associates Inc. survey of utility commissioners, 97% listed reliability as the major concern of their Commission and 69% expected competition would result in an increase in the number of customer complaints. These concerns have found expression in mandated reliability targets and performance-based rates. The number of states that have set reliability standards increased from three in 1996 to 27 states in 2001. As of 2001, 11 states had enacted penalties and awards for performance. During this period of increased regulator focus on reliability, many utilities seeking to lower costs have reduced staff, affecting as a minimum the perception of their ability to respond in a crisis. Regulators besieged with customer complaints about not being able to contact the local utility during a major storm event or the perceived lack of speed of service restoration, have been motivated to undertake or order investigations. Additionally, Public Utility Commissions are questioning whether a utility's past maintenance practices have not compounded the extent of storm damage.

The focus on reliability is likely to continue as factors converge to increase the stresses on and risks to the electrical system. The transmission component of the electrical system is experiencing unprecedented load. Due to the business uncertainty associated with evolving regulation towards competitive markets and public resistance to siting new transmission lines, expansion of the transmission system has not kept pace with growing electricity demand. With the shift to and expansion of the digital economy, reliability of the electric system takes on previously unimagined significance. The annual U.S. economic loss due to power outages is estimated to range from a conservative US$50 billion (EPRI) to US$100 billion (Bank of America). To this increased demand for quality of service during a period of increased vulnerability is added an increasing risk of major system outages caused by severe weather events. Climatologists studying global warming predict greater variability in weather in the future; that the number and severity of major weather events would increase. The trend may already be established. During the last 21 years, 48 extreme weather events each with estimated damages exceeding US$1 billion hit the United States. Of these, 41 have occurred in the last 12 years (Hadden, E. Weather Lessons. Transmission & Distribution World, Apr. 1, 2001).

Utilities in the eastern half of North America face ice storms. In the south and southeastern United States windstorms are relatively frequent events. While the stress these events place on the electrical system results in direct equipment failures, often the majority of outages associated with these events are indirect. They are the result of tree failures. In western North America, where summer forest conditions tend to be dry, tree-conductor contacts are more than a reliability risk; they are a cause of forest fires. While trees have always been a factor in the safe, reliable operation of the electric system, particularly under adverse weather conditions, a few rather spectacular events have raised awareness about tree risks. In little more than a decade, a firestorm in Washington, the burning of a historical California town, two major western U.S. grid crashes and the August 2003 eastern blackout have been attributed to tree-conductor contact.

Out on a Limb

Throughout their one hundred year history, utilities have been challenged by tree-conductor conflicts. On transmission systems tree-conductor contacts can have devastating results as demonstrated by the fact that trees were involved in the last three major cascading outage events in North America. For many utilities, trees are the number one cause of unplanned distribution outages. Across the utility industry, tree-related outages commonly comprise 20% to 50% of all unplanned distribution outages. While these percentages indicate trees are a major threat to reliability, the convention of excluding outage statistics arising from severe storm events means the extent of the problem is, in fact, understated.

It is estimated that North American utilities spend $7 billion to $10 billion (Ed. Transmission & Distribution World March 2002) annually on vegetation management to prevent service interruptions and safety hazards associated with trees contacting conductors. Considering the long history of attention and resources focused on reducing or eliminating tree-conductor conflicts, the incidence of tree-caused cascading outages and the general extent of the ongoing level of tree-related outages on the distribution system, suggests something is missing.

Tree-related outage statistics provide information about the extent of tree exposure and efficacy of the vegetation management program. However, these statistics are after the fact. What is required is a conceptual framework for sustainable tree-related outage reductions – a means of truly managing tree-related outages.

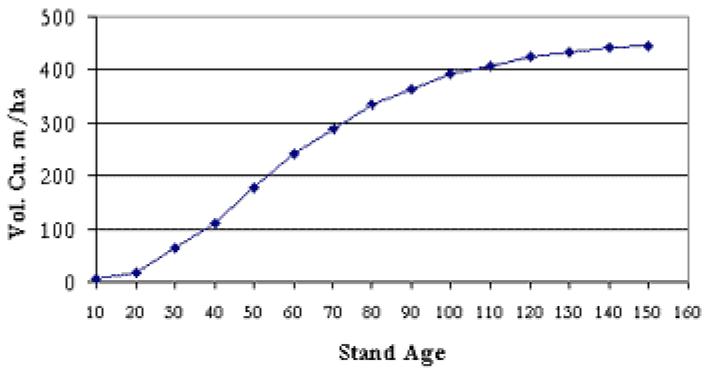
Vegetation Management Concepts and Principles

The inventory of all trees that either have the potential to grow into a power line or on failure (breakage) to strike a conductor will be referred to as the utility forest. The utility forest has the same characteristics as any forest. The same patterns of biomass addition (tree growth) and tree mortality apply. Both of these are significant factors in power line security and both can be mathematically represented by geometric progressions, as illustrated in Figure 1. Biomass addition results in trees encroaching on conductors, necessitating tree pruning and either mechanical or chemical (herbicide) brush clearing. Tree mortality produces decadent trees subject to breakage or tipping over (Figure 2). Such trees must be identified as faulty and prone to failure under weather stress and removed prior to the occurrence of stress. From a utility perspective, trees represent a liability in both the legal and financial sense. The fact that the utility forest changes by geometric progression is significant. It means the tree liability, if not managed, will grow exponentially.

Trees cause service interruptions by growing into energized conductors and establishing either a phase-to-phase or phase-to-ground fault. Trees also disrupt service when trees or branches fail, striking the line causing phase-to-phase faults, phase-to-ground faults or breaking the continuity of the circuit. As the two factors responsible for service interruptions, tree growth (biomass addition Figure 1) and tree mortality

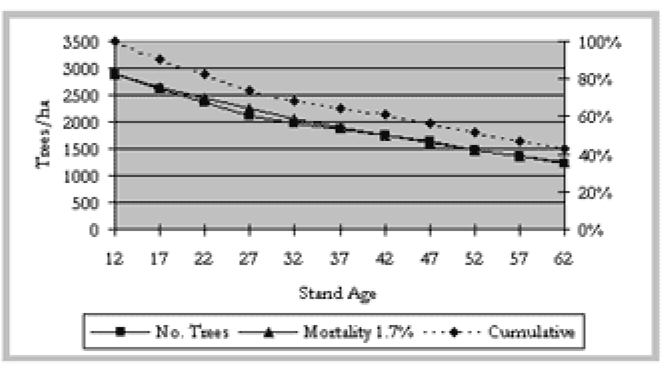
(Figure 2) change by geometric progressions, the progression of tree-related outages is also exponential. Failure to manage the tree liability leads to both exponentially expanding future costs and tree-related outages. Conversely, it is possible to simultaneously minimize vegetation management costs and tree-related outages.

Figure - 1
Forest Biomass Addition
Timber Production
Spruce on Good Site



Source: Freedman, Bill and Todd Keith, 1995. Planting Trees for Carbon Credits. Tree Canada Foundation.

Figure - 2
Stand Density
South Carolina
State Forest

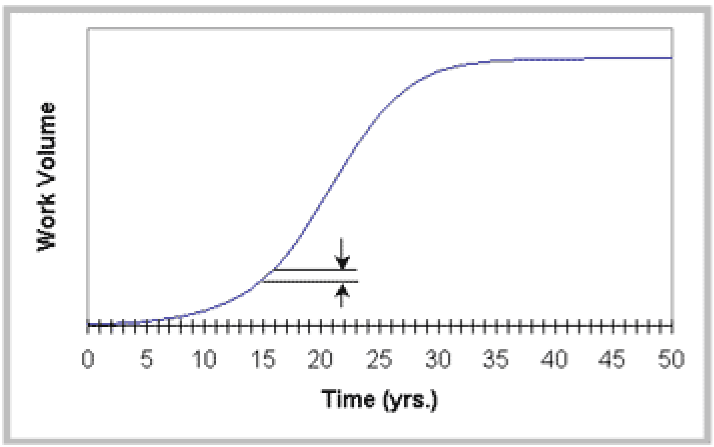


Source: Crookston, Nicholas L. 1997. Suppose: An Interface to the Forest Vegetation Simulator.
Sixty percent of the trees in the stand die over 50 years. Over 40% are tall enough to disrupt distribution service.

It is not possible to totally eliminate the tree liability because the ecological process of succession is a constant force for the re-establishment of trees from whence they were removed. The tree liability then, is like a debt that can never be completely repaid. Under such circumstances, the best economy is found in maintaining the debt at the minimum level, thereby minimizing the annual accrued interest. However, irrespective of cost, minimizing the size of the tree liability or utility forest is rarely an option for utilities due to multiple stakeholders with an interest in the trees. What can be achieved, however, is equilibrium. The tree liability can be held constant at a point by annually addressing the workload increment. To continue the debt analogy, a debt is stabilized when the annual payments equal the interest that accrues through the year. The interest equivalent in the utility forest is comprised of annual tree growth and mortality. Actions that parallel the reduction in the debt principal are actions that actually decrease the number of trees in the utility forest. Such actions include removal of trees and brush by cutting or herbicide use.

When the pruning cycle removes the annual growth increment and the danger tree program removes trees as they become decadent (Figure 3), tree-related outages are stabilized. The residual level of tree-related outages reflects the interaction of several characteristics, including the size of the utility forest, chosen maintenance standards (such clear width), tree-conductor clearance, and tree species characteristics such as mode of failure and decay. An expression of a managed tree liability, one where the annual workload increment is removed, is stable tree-related outages. Reducing tree-related outages below an achieved equilibrium necessitates actions that decrease the size of the utility forest. Actions are not limited to vegetation management. For example, increasing conductor height reduces the size of the utility forest as it reduces the number of trees capable of striking the line.

Figure - 3
Stabilizing Tree Workload



Work volume that must be completed in a year to hold tree work inventory, costs and reliability steady. Performing less than the annual workload increment shifts the total tree work inventory to the right, necessitating greater annual vegetation management expenditures to arrest the expansion of tree-related service interruptions.

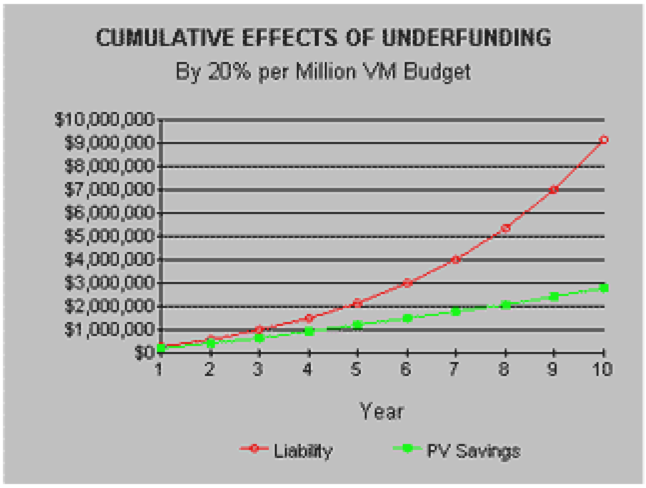
The Impact of Funding Decisions

There are three possible outcomes determined by funding assigned to vegetation management.

1. The annual workload increment is removed, keeping the size of the tree liability and next year's workload increment constant
2. More than the annual workload increment is removed, decreasing the size of the tree liability and the subsequent year's workload increment
3. Less than the annual workload increment is removed, increasing the size of the tree liability as the work not done expands exponentially increasing the workload increment for the following year Tree-related outages are an expression of the tree liability. Hence, changes in the tree liability result in proportional changes in tree-related outages.

The fact that tree liability increases by geometric progression has two major implications for future costs and reliability when less than the annual workload increment is removed. First, the impact of doing less vegetation management work than the annual workload increment, as expressed through tree-related outages, may be relatively imperceptible for a few years. Secondly, the point at which the impact of underfunding is readily observed in deteriorating reliability, is where the effect of annual compounding in the workload, and thereby costs, is large (Figure 4). The lack of a significant negative reliability response to reduced vegetation management funding may provoke further funding reductions, exacerbating the size of future re-investment required to contain tree-related outages.

Figure - 4
Impact of Underfunding Vegetation Management Revealed Over Time



Notes: Rate of change in liability based on western Canadian utility with a 4-month growing season.
Interest/Discount rate = 6%

Recognition that the tree workload expands by geometric progression serves both to explain some common utility experience and raise new questions, such as, what is the annual rate of change in the tree workload. For many utilities, graphing customer hours lost on tree-caused interruptions over the last twenty years reveals cyclical up and down trends. There are periods when trees are perceived as a problem and funding is increased. This permits a buying down of the tree liability, reducing tree risks and tree-related outages. Faced with these positive results, spending on vegetation management is reduced. While this is perfectly logical, without the conceptual framework outlined, it is inevitable that funding will be reduced to the point where there is an observable response in tree-related outages. Unfortunately, by the time that tree-related outages are observed to definitely be on an increasing trend, vegetation management funding has been less than required to remove the annual workload increment for some years. At this point the power of compounding is well underway and only a very aggressive increase in funding will arrest the trend. In stating that an aggressive response is required to arrest compounding negative effects, a rapid rate of change in tree workload is implied. The rate of change in **Figure 4** derived from data in Alberta, Canada, where the growing season is only four months long, is approximately equal to compounding at 27% per year. Warmer climates with a longer growing season support higher rates of change. These rates may exceed 40% per year. In other words, the rate of change in the tree workload is substantially higher than the discount rate one would conceivably use to derive the present value benefit of deferred maintenance spending. Taking a short-term financial perspective, any deferred or diverted vegetation management funding that inhibits removal of the annual workload increment is poorly allocated unless it provides a better rate of return. However, investments yielding 25% to 40% rates of return are anything but commonplace.

Managing the Tree Liability for Positive Returns

Trees need to be recognized as a liability in a utility context. While this puts utilities in conflict with community perceptions of trees as assets, the conflict does not change the fact that trees hold only the capacity to impair the safe, reliable operation of the electric system, not to augment it in any way. Recognizing and quantifying the utility forest as a liability provides a measure of the potential for, or risk of, tree-conductor conflicts. Furthermore, it connects and clarifies the influence of design and operating decisions on maintenance costs and reliability risks.

Managing the tree liability necessitates an understanding of how and where tree risks arise, a quantification of the extent of tree exposure, the rate of change in the tree liability and a commitment to funding that permits as a minimum the removal of the annual workload increment.

While some utilities have inventories of trees occurring within rights of way, none have a full measure of their entire tree exposure. And while three cascading transmission outage events would suggest trees growing directly underneath conductors are the major source of tree-caused outages, the facts are that trees from outside rights of way account for the vast majority of tree-related outages. Managing trees beyond the right of way is problematic as such management may conflict with the interests of the landowner. Nonetheless, a prerequisite to effectively managing any problem is its identification and quantification. Managing tree-caused service interruptions will necessitate measuring the entire tree exposure and committing resources accordingly.

Proper funding of vegetation management is one of the best investments a utility can make. It serves to minimize tree-caused interruptions for the chosen clearance standard, thereby avoiding customer complaints, regulator intervention and performance penalties. It avoids the inefficiencies inherent in the cycle of allowing trees to become a major problem, getting trees under control by buying down the tree liability and then losing the investment by failing to contain the tree liability. For example, returning reliability to the original level after 10 years of underfunding by 20% as shown in **Figure 4** escalates costs by 80% over funding that permits the annual removal of the tree workload increment. Funding based on the removal of the annual tree workload increment manages the tree liability, providing the lowest incidence of tree-caused service interruptions. Additionally, funding vegetation management based on the annual workload increment has a positive bottom line impact that over the long run benefits both shareholders and ratepayers.