Attachment Staff 1-29-1
R E D A C T E D

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Unitil Energy Services Corporation
New Hampshire

Distribution and Sub-Transmission Vegetation Management Program

Prepared for
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Unitil Energy Systems – Executive Summary

1.0 Introduction

ECI has completed a comprehensive study to evaluate Unitil-New Hampshire's (Unitil-NH) distribution and sub-transmission vegetation management program in the state of New Hampshire. The study included an examination of distribution vegetation management practices, policies, operating procedures and a review of current work techniques. ECI also documented the amount and type of vegetation requiring control on the primary overhead distribution system. In addition, Unitil-NH tree-caused interruptions data and local tree species regrowth were examined.

The Unitil electric distribution system in New Hampshire includes 1,050 pole miles of primary overhead distribution and 110 miles of 34.5kV sub-transmission. Unitil currently has a split line clearance maintenance cycle based on voltage and construction type. The current cycle break-out is: 4kV three-phase = 8 years; 4kV single-phase = 10 years; 13.8 kV three-phase = five years; 13.8 kV single-phase = 7 years; 34.5 kV three-phase = 4 years and 34.5 kV single-phase is a 5 year cycle.

The primary goal of this study was to identify an optimal vegetation management strategy for the entire Unitil-NH distribution and sub-transmission system and project associated budgets and reliability improvement. Solutions examined were based on information gathered by ECI from the Unitil-NH system, data provided by Unitil-NH, industry best practices and ECI's extensive experience and research.

This section contains a brief synopsis of the findings and recommendations resulting from this study. A detailed discussion of these vegetation management program recommendations can be found in Section 4.

1.1 Key Findings

On the basis of this evaluation, our experience evaluating more than 160 other programs, and comparison with other utilities and benchmark groups, it is evident that Unitil-NH has taken steps to establish important elements of a good distribution vegetation management program. Several observations brought us to this conclusion: standard operating procedures and practices; technically correct pruning practices; proactive and systematic scheduling of preventive maintenance work; effective "reliability enhancement" in consultation with system reliability engineering; and minimal devotion of resources to maintenance of trees near service lines.

Despite having many aspects of a good program, examination of Unitil-NH data and comparison to industry benchmarks reveals areas in need of improvement. These include inconsistent line clearances due to customer concerns, projected increases in workload due to lack of herbicide use, and above-average rates of tree-caused outages, and high cost per mile maintained. ECI has explored Unitil-NH's tree-related reliability and several other issues in great detail in Section 3. Many of the key findings, which lead to recommendations for improvement, are as follows:

- Unitil-NH has a decentralized vegetation management (VM) program. Best in class utilities have a centralized VM program.
- Unitil-NH does not have a utility arborist / forester.
- Tree-caused outage rates, whether measured by interruptions per 1000 trees or interruption per 100 line miles, are much higher at Unitil-NH than utility averages and significantly higher than the best utilities.
- Present lack of herbicide usage following brush and tree removal results in increased workloads and maintenance costs in future cycles.
- Unitil-NH record keeping lacks the collection of certain important information related to work crew production. For example, the collection of unit production data would allow movement toward more performance-based contracting.
- Collection and transfer of contractor production data from the field to final Excel spread sheet requires manual input and is labor intensive.
- The collection of more and improved tree-caused interruption data would assist in providing an understanding of how trees cause outages on the Unitil-NH system. Follow-up investigations by qualified utility arborist would assure accuracy and allow the future identification of specific tree conditions most commonly associated interruptions.
- Unitil-NH's number of internal and contractor supervisors compared to work crews is lower than much of the industry and lower still compared to the most effective maintenance programs.
- Lack of VM oversight has resulted in the following program deficiencies: failure to follow-up and resolve customer pruning concerns; failure to pursue tree and brush removal; failure to use herbicides as a vegetation management tool due to the lack of man-power to set up the notifications and follow state regulations; inadequate post-pruning Q/A; limited time for pre-planning and circuit review prior to pruning.
- The current "work area protection" cost mandated by the majority of local municipalities adds significant cost to the Unitil system vegetation maintenance cost per mile.
- Unitil-NH is not able to meet cyclic goals due to inadequate VM funding (work area protection cost contributes significantly to this problem). This has resulted in approximately 13 percent of the tree population growing within 2 feet of the conductors and 38 percent growing within 5 feet of the conductors.

1.2 Key Recommendations

ECI's assessment leads to 13 recommendations to Unitil-NH and are listed below:

1. Begin to maintain single-phase 4kV lines on shorter cycle emphasizing the removal of more trees (from 10-year to 7-year cycle).
2. Begin to maintain 13.8kV multi-phase lines on a shorter cycle emphasizing the removal of more trees (from 5-year to 4- year cycle).
3. Implement a mid-cycle program for the multi-phase lines to inspect and prune the "cycle-buster" trees that will grow into the conductors prior to the next cyclic pruning. Include a mid-cycle inspection of single-phase circuits and provide clearance at poles containing critical equipment (transformers, etc.).
4. Implement an enhance clearance standard for Red Maple. Based on the rapid re-growth rate of this species, greater clearance at the time of maintenance will help extend the average cycle length.
5. Consider increasing side clearance from 8-feet to 10-feet. This will allow for a 5-year cycle vs. a 4-year cycle (as determined by species re-growth rates on the Unitil-NH system).
6. Establish a hazard tree identification and mitigation strategy. Hazard and danger trees contribute significantly to Unitil-NH's tree-caused outages. Developing an inspection, rating and prioritized hazard tree removal program will improve system reliability. Use of a hazard tree rating system at the time of evaluation and prioritizing based on voltage and number of phases present (highest voltage multi-phase to the single-phase lower voltage areas) will help allocate resources based on risk and benefits. By developing a multi-year expenditure strategy, the initial high cost of removal can be spread over several years.
7. Continue a reduced Reliability Enhancement Trimming process; reviewing the worst performing circuits due to vegetation. Limit to three-phase circuits, prioritized based on tree-caused customer interruptions per mile. These circuits should be considered for the current years cycle, move out circuits with better reliability performance. This practice should continue to be a joint effort with Operations and Reliability engineering.
8. Establish the position of System Arborist and provide the individual with the authority to implement and oversee the recommended vegetation management program. In addition, assign one full-time Regional Arborist (preferably two: one per Region) to assist the System Arborist implement the vegetation management program and provide QA/QC on contract line clearance work.
9. Begin to utilize herbicides to control stump sprouts and standing brush where appropriate. Apply Integrated Vegetation Management (IVM) principles on the Unitil-NH system, especially the sub-transmission.

10. Expand the newly established mail method of property owner notification to include more personal contact and use of door cards prior to tree removal or heavy pruning.
11. Enhance the record-keeping systems for line clearance in order to maintain comprehensive records of production, and use this enhanced data for program management and to document contractor performance. Switch to miles and trees/brush units worked as measures of contractor performance rather than the current units (spans) being utilized. This is extremely valuable in establishing production and cost standards for specific work units (trees trimmed per man-hour, trimming cost per unit of top or side pruning, tree removal cost based on size class, etc.). Adopt work planning, record keeping and auditing practices that optimize work quality and cost-effectiveness.
12. Establish an ongoing work acceptance process (QA/QC) designed to formally document and confirm work quality and work completion to established standards, such as: compliance with clearance standards; appropriate tree removals are being carried out; effective application of herbicide to cut. Establish a ratio of crews to supervision that is appropriate for the number of production resources utilized.
13. Begin to conduct tree-related interruption autopsies to provide data regarding specific characteristics of trees that fail, and use that data to better target the enhanced maintenance program toward that portion of the tree population that is most prone to fail and cause outages. This includes enhanced/expanded vegetation outage record keeping to provide more details on types of tree outages (i.e. growth, broken limb, broken trunk, up-rooted tree) as well a location of the tree that caused the outage (on or off the right-of-way).

Following adoption of an appropriate maintenance strategy, consistently fund the program accordingly.

Detailed recommendations are presented in Section 4. Issues addressed by these recommendations fall into three general areas. Addressing these issues will provide the foundation for a program that will improve reliability and control costs. These three areas of particular concern are as follows:

1. System Reliability
2. Scheduling
3. Supervision and Planning

1.3 System Reliability

ECI performed a thorough study of Unitil-NH’s reliability data. In general, tree-caused outages are higher at Unitil-NH than at other comparable utilities. In particular, tree-caused interruptions on Unitil-NH multi-phase lines are much more common than on single-phase lines. Figure 1-1 illustrates the difference in outage frequency between line types.

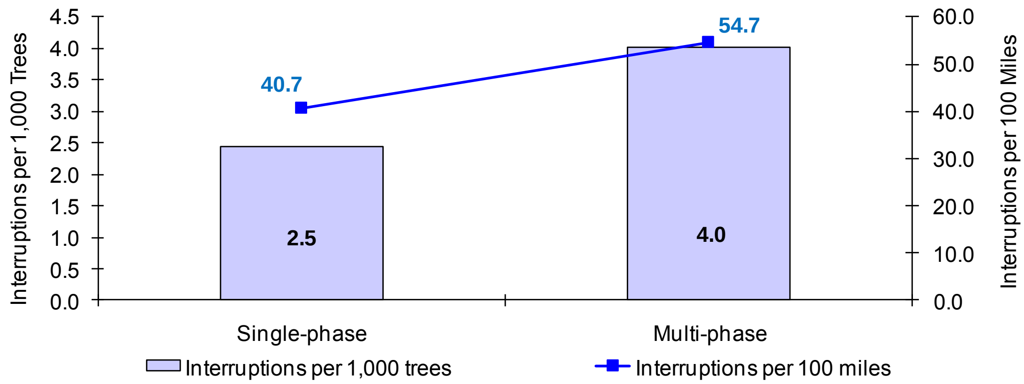


Figure 1-1. Mean Three-year Storm & Non-storm Outage Frequency per 100 Miles and per 1,000 trees for Single-phase and Multi-phase Standard Maintenance Test Circuits (Average 2007-2009)

These single-phase outages should be addressed through a shorter maintenance cycle and a modified mid-cycle approach where trees near critical facility infrastructure such as transformers are pruned or removed. The multi-phase outages should be addressed through several program changes: change in maintenance cycle for 5-year to 4-year; mid-cycle pruning program addressing the fastest growing; removal of hazard trees on the multi-phase system over 3-years and selective removal of overhanging limbs on critical circuits and on weak-wooded tree species. Unitil-NH has a pilot "reliability enhancement" program where multi-phase circuits that have very poor reliability performance are reviewed with engineering to determine causes (vegetation, construction) and targeted solutions are developed and executed to resolve the issues. Analysis of data suggests that Unitil-NH would also benefit from extending the side-clearance zone from 8-feet to 10-feet. The largest contributing factor to Unitil-NH poor reliability performance is hazard trees (broken limbs, trunks, up-rooting).

One key to efficient long-term maintenance of acceptable tree-caused interruption levels and controlling maintenance cost is the use of herbicides to control resprouting of brush and tree removals. Without herbicide treatment, stem counts of tall-growing species only increase with time, limiting right-of-way (ROW) access and increasing costs. A detailed discussion of the reliability data is provided in Sections 3.4 and a detailed discussion of clearances, herbicide use and hazard trees can be found in Section 4.2.

1.4 Scheduling

Two issues related to scheduling should be addressed. The first is to limit reactive, non-scheduled maintenance. Completion of non-critical maintenance requested by customers does not normally result in improved reliability.

The second issue is the primary purpose of this study: To determine the optimal schedule and associated budgets necessary to improve reliability. Based on results of the study, ECI has developed the following cycle strategy recommendation:

- 7-year single-phase & 4-year multi-phase Scheduled Vegetation Maintenance.

- Mid-cycle inspection and pruning of all multi-phase and selected single-phase pole locations with critical equipment (transformers, cut-outs, etc.).
- Brush removal (on multi-phase 1/4th of system per year for 4) ;(on single-phase beginning year 5 start a 7-year brush removal program).
- Hazard tree removal on multi-phase (1/7th of system per year for 7 years @ year 8 expand hazard tree program to single-phase as well as multi-phase).
- 4-year cycle for the sub-transmission.

This recommendation assumes prioritization of circuits according to factors including recent CI, construction type and line voltage. Cost projections were made for various options, as well as the projected impact on tree-to-conductor contact, tree-related outage events and tree-related CI. ECI's recommendations are based on the Unitil-NH system data analyzed and our vegetation management experience in conduction over 160 similar utility studies. Figure 1-2 illustrates projected reduction in non-storm CI on single-phase lines for Option I (ECI Recommended) and Option II. Figure 1-3 illustrates the projected reduction on multi-phase lines under Option I (7-Year hazard tree program) and Option II (3-Year hazard tree program).

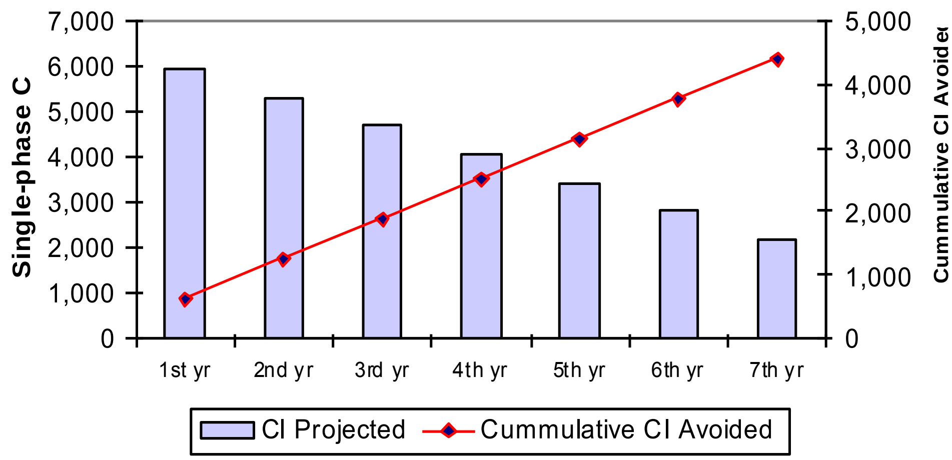
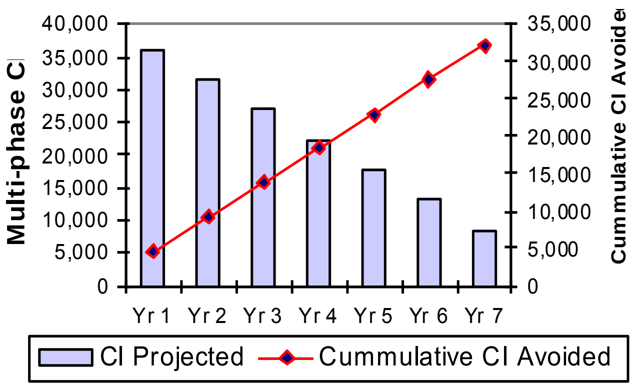


Figure 1-2. Unitil-NH Projected Non-storm Tree-caused Customer Interruptions (CI) Projected vs. Avoided per Year For Single-phase Maintenance (applies to Option I & II)

I. Multi-Phase - CI Projected (over 7- years)



II. Multi-Phase - CI Projected (over 3-years)

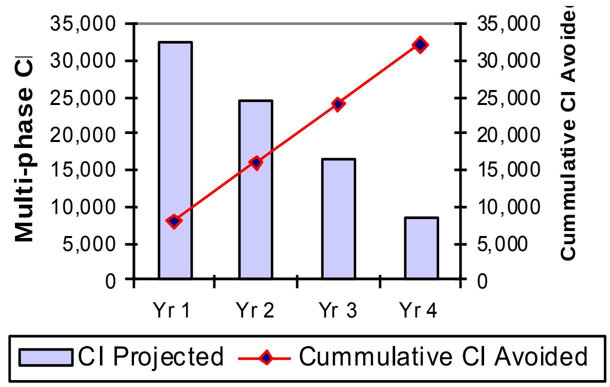


Figure 1-3. Unitil-NH Projected Non-storm Tree-caused Customer Interruptions (CI) Projected vs. Cumulative CI Avoided per Year for Multi-phase Maintenance. I. Show Impact of a 3-year Hazard Tree Removal Program; II. Shows Impact of a 7-Year Hazard Tree Removal Program.

It is ECI's opinion the greatest improvement in reliability, while maintaining relatively low long-term annual cost is provided in Option I. This recommendation offers: minimal changes from the existing program; minimal impact to customers and the environment; quick and cost effective reductions in vegetation cause outages; reduced long-term vegetation workload without sacrificing public and worker safety. Table 1-1 presents a summary of this recommendation. Option II on the other hand provides the quickest system reliability improvement through an accelerated hazard tree removal program (over 3-years vs. 7-years).

Table 1-1. ECI Program Strategies

Options	*Cycle Description*
ECI Recommended Program Strategy ***Option I*** *Gradual Impact on system Reliability at a lower annual cost. (7-Year Hazard Tree Removal Program)*	• 7-year singe-phase & 4-year multi-phase Scheduled Vegetation Maintenance program (NOTE: an increase in side-clearance distance on multi-phase from 8-feet to 10-feet will provide adequate clearance for a 5-year cycle based on system re-growth rates). • Mid-cycle prune all multi-phase and selected single-phase pole locations with critical equipment (transformers, cut-outs, etc.). • Brush removal on multi-phase and single-phase; • Hazard tree removal on multi-phase (1/7th of system per year for 7 years @ year 8 expand to include single-phase). • 4-year cycle for the sub-transmission. Optional: Removal of tall-growing tree species on ROW under conductors (currently being top-pruned): 4-year cycle on multi-phase and at year 4 start an 8-year removal program on single-phase.
Option II: *Quickest Impact on System Reliability at a higher annual cost.* *(3-Year Hazard Removal Program)*	• 7-year single-phase & 4-year multi-phase Scheduled Vegetation Maintenance program (NOTE: an increase in side-clearance distance on single-phase from 8-feet to 10-feet will provide adequate clearance for a 5-year cycle based on system re-growth rates). • Mid-cycle prune all multi-phase and selected single-phase pole locations with critical equipment (transformers, cut-outs, etc.). • Brush removal on multi-phase and single-phase; • Hazard tree removal on multi-phase (1/3rd of system per year for 3 years @ year 4 expand to include single-phase). • 4-year cycle for the sub-transmission. Optional: Removal of tall-growing tree species on ROW under conductors (currently being top-pruned): 4-year cycle on multi-phase and at year 4 start an 8-year removal program on single phase.

1.5 Supervision and Planning

ECI recommends establishment of a ratio of crews to supervision (Unitil / contractor general foreman) that is appropriate for the number of production resources utilized. As budgets may increase during a "catch-up" period and then decrease again as the maintenance strategy stabilizes, the number of supervisors should increase or decrease accordingly. Under the ECI recommendation, 12 crews are required, a doubling of the current contractor work force. Implementation of this recommendation and the ability to realize the full benefits of this program would require the addition of a system arborist and one regional arborist to implement and manage this program. Depending on the level of lump-sum work, an additional temporary work-planner may also be required.

1.6 Estimated Costs

Based upon ECI's vegetation workload study and information provided by Unitil-NH, ECI's recommended management strategy shown in Table 1-2 provides the greatest benefits for the least cost. This strategy would involve increasing the line clearance budget from 2010 levels to accommodate more intensive vegetation maintenance practices, including shorter cycles for single and multi-phase line segments, introduction of a mid-cycle program, aggressive hazard tree removal program, and the implementation of Integrated Vegetation Management principles including the use of herbicides. Assuming herbicides would begin to be used for stump treatment following tree and brush removal and an aggressive hazard and mid-cycle program are adhered to, cost reductions are projected in the second and third cycles. These practices would all improve system reliability, and in some cases, such as with herbicide use, long-term savings would outweigh short-term costs. These recommendations are discussed in-depth in Section 4.6. The two most important recommendations for Unitil-NH are: providing consistent and adequate funding; and the aggressive removal of hazard trees on the system. As conditions change, requiring modification of the strategy, changes in funding should be made accordingly.

Table 1-2. Comparison of Expenditures ($ 1,000) Required for Implementation Of Two Alternative Management Strategies[1]

Management Strategies ➔	**ECI Recommended Program Option I** [1] 4-Year multi-phase 7-Year single-phase + Multi-phase Mid-cycle and targeted single-phase mid-cycle + hazard tree removal on three-phase (1/7th per year)	**Option II** 4-Year multi-phase 7-Year single-phase + Multi-phase Mid-cycle and targeted single-phase mid-cycle + hazard tree removal on three-phase (1/3rd per year)
1st cycle [2]		
Number of crews required:	8	12
Scheduled	$1,246	$1,246
Mid-cycle	$138	$148
Un-Scheduled	$40	$40
Brush	$20	$20
Hazard Tree removal	$800	$1,755
Reliability Enhancement	$100	0
TOTAL DISTRIBUTION	$2,344 [3]	$3,199 [3]
Sub-transmission	$80	$80
TOTAL VM PROGRAM [6]	$2,424	$3,279

NOTES

[1] Costs expressed in 2010 dollars.
[2] Based on the workload projections (i.e., number of trees and acres of brush) and the average man-hour cost per tree pruned of $68.84. This is based on Unitil crew production rate of .68 MH/tree (weighted average of on-road and off-road production) and the MH cost of $36.27 per MH for contractor crew + Work Area Protection (police) $52 per MH. These costs were distributed uniformly over the specified cycle by appropriate work type and associated miles. The projections do not include incidental secondary/service maintenance or costs for management and supervision.
[3] Approximate Unitil-NH for 2009 distribution maintenance: $714,000.
[4] CI 2007-2009 average for tree caused was 47,331 at Unitil-NH (non-storm) as calculated by ECI using Unitil data. Cycles: 7-year 1Ø & 4-year 3Ø.
[5] Reliability improvement implementing this recommendation is projected to be 10% CI for single-phase and 20% for multi-phase per the respective 4 and 7 year cycles. This includes a hazard tree removal component: Option I is a 7-year hazard removal program; Option II is 7-year hazard removal program. Both provide the same results only on different timeframes.
[6] Implementation of the program recommendation will require the addition of a system arborist and a regional arborist or the addition of 2 work planners. Estimated cost per year is approximately $100,000.

Unitil Energy Systems - New Hampshire

SECTION 2:

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Unitil Energy Systems – New Hampshire

2.0 Introduction

Unitil Energy Systems (Unitil) contracted with ECI to complete a comprehensive review of its distribution and sub-transmission vegetation management program in the state of New Hampshire, with the goal of identifying an optimum vegetation maintenance strategy and identifying opportunities for improvement. ECI has completed similar studies for more than 160 electric utilities around the world. ECI's study involved an in-depth evaluation of Unitil's operating procedures, work practices and vegetation workload.

Unitil also requested that ECI develop an optimal maintenance strategy. This is based on utilizing ECI's growth simulator model to determine optimum cycle based on species regrowth rates on the Unitil system. ECI is also charged with a review of current vegetation maintenance clearance specifications and recommending enhancements to maximize system reliability while maximizing cost efficiencies of the vegetation maintenance program.

The Unitil electric distribution system in New Hampshire includes 1,050 pole miles of primary overhead distribution and 110 miles of 34.5kV sub-transmission. Unitil currently has a split line clearance maintenance cycle based on voltage and construction type. The current cycle break-out is: 4kV three-phase = 8 years; 4kV single-phase = 10 years; 13.8 kV three-phase = five years; 13.8 kV single-phase = 7 years; 34.5 kV three-phase = 4 years and 34.5 kV single-phase is a 5 year cycle. Unitil reports that resource levels have been insufficient to accomplish these cyclic targets and have resulted in maintenance deferral of some circuits. Figure 2-1 provides a look at the Unitil-NH System breakdown by voltage as well as the Capital and Seacoast Regions.

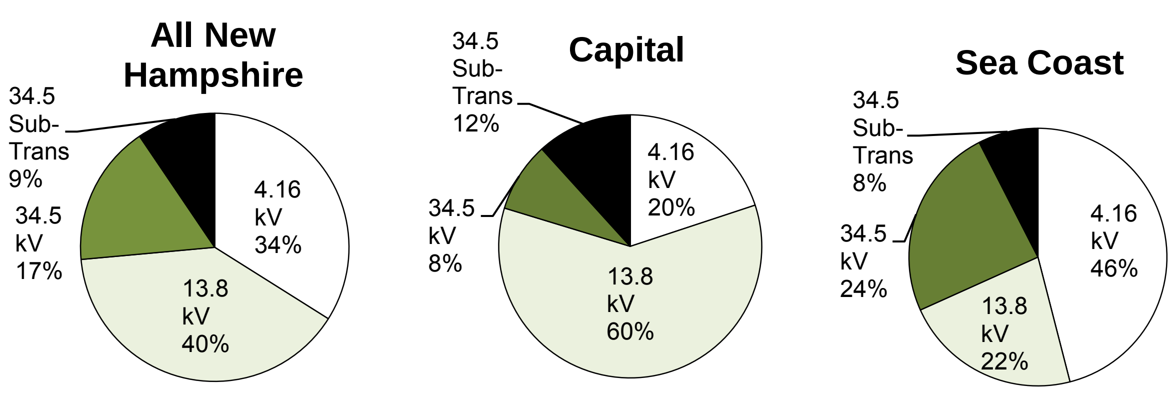

Figure 2-1. Unitil-NH Voltage breakdown

2.1 Project Purpose

This report presents an overview of the Unitil New Hampshire's (Unitil-NH) distribution and sub-transmission vegetation management program. ECI conducted a comprehensive study of the Unitil-NH program from March through April of 2010. The results of this study and the recommendations for enhancing the line clearance program, with an emphasis on optimal vegetation management cycle length and corresponding budget requirements, are presented in this report.

The following vegetation management program elements have been evaluated:

- Program management
- Vegetation workload
- Scheduling practices
- Field procedures
- Public relations
- Budgeting
- Record keeping.

Field surveys conducted by ECI provided the required data for projection of the existing vegetation workload, as well as the tree contractors' resources and budget required for its management. Analysis of Unitil tree-caused interruption data and a study of tree growth were completed to aid in development of the appropriate cycle length and cost options for the program.

2.2 Report Organization

This report has been divided into five main sections.

- **Section 1: Executive Summary** – Unitil-New Hampshire's current operational procedures and presents recommended improvements designed to encourage the continued development of a long-term, cost effective distribution and sub-transmission vegetation management program.
- **Section 2: Introduction** – Project purpose, report organization and methodology.
- **Section 3: Analysis of Present System** – Vegetation workload on the Unitil-New Hampshire system, and presents re-growth data, reliability data and program expenditure histories.
- **Section 4: Recommendations** – Management-oriented section that briefly presents specific recommendations designed to enhance the long-term cost effectiveness of the Unitil-New Hampshire line clearance program.

- **Section 5: Appendix** – Supplemental material to further clarify items referred to in this report.

2.3 Study Methodology

ECI's study of the Unitil-NH vegetation management program included an in-depth field survey of the current vegetation workload on their primary overhead distribution and sub-transmission systems. Included is a review of existing field practices, operating procedures, historical data, and interviews with Unitil-NH operations and key management personnel.

2.3.1 Office Data

Unitil-NH supplied historical data required for program evaluation. The requested documentation was discussed between ECI's project management team and Unitil-New Hampshire management staff. Additional information, including staff recommendations and suggestions for improvement, was obtained during interview sessions with the Unitil staff responsible for vegetation management oversight.

ECI's extensive library and resource base of practical experiences in the vegetation management industry were utilized, in conjunction with the information provided by Unitil-NH, in the analysis of Unitil's current vegetation management program. Comparisons were made with other utility vegetation management programs in the Northeast and throughout the rest of the country to assess the efficiency and efficacy of the existing program.

2.3.2 Field Data

Field surveys were performed to assess the existing vegetation workload. A growth study was also completed to determine the rates of regrowth following top and side pruning for major tree species on the Unitil-New Hampshire system.

2.3.3 Vegetation Workload

Vegetation conditions at points randomly located throughout the Unitil-NH system were sampled for this survey. Survey sample points were distributed between the Capital and Seacoast regions. Data was collected in 2010. A joint survey team consisting of an ECI employee and a Unitil-NH supplied driver was utilized to ensure validity of sample locations and maximize collection speed (and safety along the roadways).

This survey was designed to estimate the existing vegetation workload on Unitil-New Hampshire's primary overhead distribution and sub-transmission system. Although data was collected from each of the two regions, the sampling procedure was designed to achieve an overall, system-level tree workload projection. Data was collected to insure that this projection achieved a level of accuracy within ±10 percent error at a 95 percent confidence level.

2.3.4 Re-growth Data

A study of the rate of tree re-growth was conducted on the Unitil-New Hampshire system in conjunction with the 2010 workload study. During the field portion of this study, sample measurements were taken from trees that had been previously pruned away from the conductors. Measurements were taken only from tree species identified through the workload survey as being among the most common species on the Unitil-NH system (4 species representing 70-percent of all trees). Annual regrowth after from time of pruning for both side and top pruning was measured for each of the fours selected species selected species. Multiple measurements for both of these pruning types were taken from each species selected. These measurements were taken from both Capital and Seacoast regions to ensure that no significant differences in re-growth rates exist from one district to another. This data was supplemented with regional regrowth data from other utilities as well (where there were insufficient samples available on the Unitil-NH system).

2.3.5 Cycle Optimization

Tree re-growth rates, together with vegetation workload characteristics and interruption data, were utilized to model the impact of various pruning cycle options. Unitil-New Hampshire's unit cost production was measured through the use of special timesheets provided by ECI and analyzed using ECI's Trim Report & Evaluation System (TRES). However, based on the timeframe available, the unit costs derived from this data represented a small sample. Therefore, Unitil's unit cost production was combined with regional unit cost data (from utility with similar species and site conditions) in the development of cost projections for various modeled options.

Unitil Energy Systems - New Hampshire

Section 3:

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Unitil Energy Systems – New Hampshire

3.0 Analysis of Present System

This section contains four components: (1) a brief overview of the organization and operation of the line clearance program, (2) detailed information on the quantity and condition of the vegetation workload, (3) an examination of Unitil-New Hampshire's (Unitil-NH) tree-related outage data, and (4) a review of program expenditures over recent years.

3.1 Program Organization and Operation

3.1.1 Organization

Unitil-NH's service territory is divided into two regions, Capital and Seacoast. The responsibility for vegetation maintenance resides with the respective Operations Manager for the region. The actual day-to-day oversight is handled by a field supervisor who reports to the regional operations manager for each region. The field supervisor is responsible for scheduling and some cursory pre-work review, customer notification, handling customer inquiries, performing post trim audits, coordinating line clearance trimming requirements for construction work orders and reliability enhancement trimming, and follow-up to trimming refusals. Vegetation management represents only a portion of the field supervisors time, the remainder of their time is devoted to new business related issues, new construction projects, the dig-safe program, pole inspection and substation weed control. The approximate time spent on vegetation management varies but on average the field supervisors collectively feel they spend 30 percent of their time on the vegetation management program. Each of the two regions have between 2 to 3 hourly contract tree crews that perform cyclic distribution maintenance, capital/work order pruning, reliability enhancement pruning, customer ticket requests and storm response. The distribution pruning program was a mix of hourly (88 percent) and lump sum (12 percent) contracts in 2009 (this is an increase of 6 percent in lump sum contracts from 2008). The distribution line clearance contractor has a non-billable part-time General Foreman for crew supervision and this individual is responsible for pre-screening customer requests for tree work. When the General Foreman gets more than two weeks behind in responding to these customer requests, another line clearance employee is added on a short-term basis to get caught up on the back-log of customer pruning requests.

3.1.2 Work Scheduling

The work is generally scheduled based on cycle. The cycle varies by voltage and construction type (three-phase / single-phase). Table 3-1 shows the current cycle length by voltage. Based on this combination of voltage and construction type, Unitil-NH should be pruning approximately 150 miles per year. The 2007 to 2009 three-year average is 71 miles. Based on the three-year average accomplishment per year, Unitil-NH completed approximately 47 percent of the mile required to meet cycle goals or a 53 percent deficit in miles completed against cyclic goal.[1]

[1] 2008 represents a lower than normal percentage of completion due to a system-wide ice storm and 2009 was higher normal in an attempt to recover the planned miles lost in 2008.

Table 3-1. Unitil-NH Current Distribution Cycle by Voltage

	Cycle	
Voltage Class	*Three-phase*	*Single=phase*
4 kV	8 YEARS	10 YEARS
13.8 kV	5 YEARS	7 YEARS
34.5 kV	4 YEARS	5 YEARS

Other utilities in the Northeast follow different cycle guidelines. The following is a sample of other NE utility vegetation maintenance cycles:

Central Maine	5-year cycle
Central Hudson	5-year cycle
Commonwealth Electric (MA)	4-year urban and 5-year rural cycle
Public Service New Hampshire	Averages 5 years
National Grid	5-year cycle with mid-cycle
New York Power Authority	4-year cycle
North East Utilities	4-year cycle
Ontario Hydro	3-year urban and 6-year rural
Orange & Rockland	4-year cycle
Rhode Island	4-year urban and 6-year rural

In addition to standard distribution maintenance cyclic work, Unitil-NH performs unscheduled maintenance (customer tickets, hazard trees and reliability enhancement work) and sub-transmission right-of-way (ROW) maintenance.

3.1.3 Contract Crews

As 90 percent of the work is accessible to a lift vehicle, the 2-person bucket crew is standard crew complement on the Unitil-NH distribution system. Larger crews are formed as needed for occasional off-road work, large tree removal and other specialized types of work where more than a 2-person crew is required for safety or efficiency. Approximately 90 percent of the work is accomplished on an hourly contract basis. The remaining work is comprised of firm priced work on a circuit basis.

At the time of this analysis there were approximately 6 hourly contract tree crews (2-person bucket crews) operating throughout the Unitil-NH system. Lump sum contract staffing levels are variable and include a combination of standard bucket trucks, specialized off-road equipment and climbing crews. Lump sum has accounted for approximately 12 percent of the budget in 2009 and 2010. Currently the contract supervisor spends approximately 60 percent of his time on the Unitil-NH system.

3.2 Distribution System Workload

The tree and brush workload on the Unitil-NH distribution and sub-transmission system was estimated statistically on the basis of random sample surveys conducted across Unitil-NH's 1,161 miles of primary overhead distribution/sub-transmission system. Workload projections were calculated based on the 1,051 line miles of distribution overhead. For the purposes of this survey, brush was defined as plant growth under four inches d.b.h., maturing at 20 feet or more. Brush was measured in quarter span increments.

3.2.1 Tree Workload

ECI projects that there are approximately 162,000 (± about 10,000) total trees on the 1,051 miles of line that comprise the Unitil-NH primary overhead distribution system. These are the trees under and along the Unitil-NH overhead distribution system that require maintenance to prevent vegetation-caused interruptions. Table 3-2 summarizes the vegetation workload on the Unitil-NH distribution system.

Table 3-2. Projected Vegetation Workload on the Unitil-NH Primary Distribution System

	Tree Pruning	*Tree Removal*[2]	*Hazard Trees*[3]	*Total Trees*	*Overhang*	*Brush*[4] *Acres*	*% Error*[5]
Unitil - NH Distribution System	129,000	1,000	32,000	162,000	9,100	60	± 6%

Figure 3-1 provides a comparison of tree densities with other utilities. Of the 100+ utilities inventoried by ECI, the average tree density is 90-95 trees per mile, indicating Unitil-NH tree density (154 per mile) is above average for the industry. Utilities with the highest tree densities are located primarily in the northeastern United States.

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[2] In general, good candidates for removal will be small diameter trees in rural areas. Fast-growing trees in urban or rural areas may also be good candidates for removal regardless of diameter, especially if they would require top pruning. The number of hazard trees on the system is a huge driver of reliability.
[3] Tree(s) that are obviously dead or dying and could come in contact with the conductors when they fail.
[4] A woody plant less than 4 inches diameter (d.b.h) that may reach the conductor at maturity.
[5] Percent Error is +/- sampling error of the estimated number of trees per mile at the 95% level of confidence (Actual ECI survey results = +/- 6.4 %).

Trees per Mile

Figure 3-1. Comparison of Unitil NH's tree density with other utilities and the industry as a whole.

Line construction, growth rate, pruning type, species composition and clearance characteristics shape the approach to vegetation maintenance. By understanding the system make-up or characteristics, a strategy can be developed to maximize the vegetation management effort and provided a more directed approach to improving system reliability. Unitil-NH overhead distribution system consists of 68 percent single-phase construction and 32 percent multi-phase construction. Based on the results of ECI's system survey the trimming characteristics are: 67 percent side-trim; 12 percent top-trim; 20 percent hazard tree removals; and 1 percent other removals. Of the total trees listed above, 6 percent were found to be overhanging the conductors. Appendix 5.1 provides some of the system characteristics. Figure 3.2 provides a look at the Unitil-NH System breakdown of trees by construction type. The conclusion that can be drawn from Figure 3.2 is that density is slightly higher on single-phase lines (72 percent of the trees are on 68 percent of the line miles).

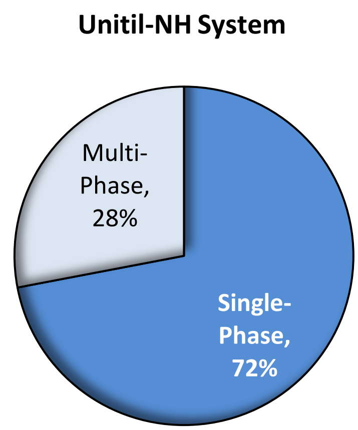


Figure 3-2. Unitil-NH Tree Density Breakdown Single-phase/Multi-phase Construction.

3.2.2 Species Composition

Unitil-NH's distribution system has a diverse tree species composition making up the tree workload. ECI recorded over 23 different species of tall-growing trees on the system. Figure 3-3 shows a comparative view of species mix as a percent of the total tree population. Species are listed in order of relative frequency encountered during the survey. The most common tree species on the Unitil-NH distribution system are listed in Table 3-3 on the following page.

Deciduous species most frequently encountered on the Unitil-NH system include northern red oak, red maple, aspen, sugar maple, birch and black cherry. These six deciduous species account for about 61 percent of the total tree workload.

Coniferous trees (pines and other evergreens) are also found on the distribution system. They comprise about 35 percent of the total tree workload. The most commonly occurring conifers include eastern white pine and spruce species. Eastern white pine accounts for 32 percent of total Unitil-NH system workload.

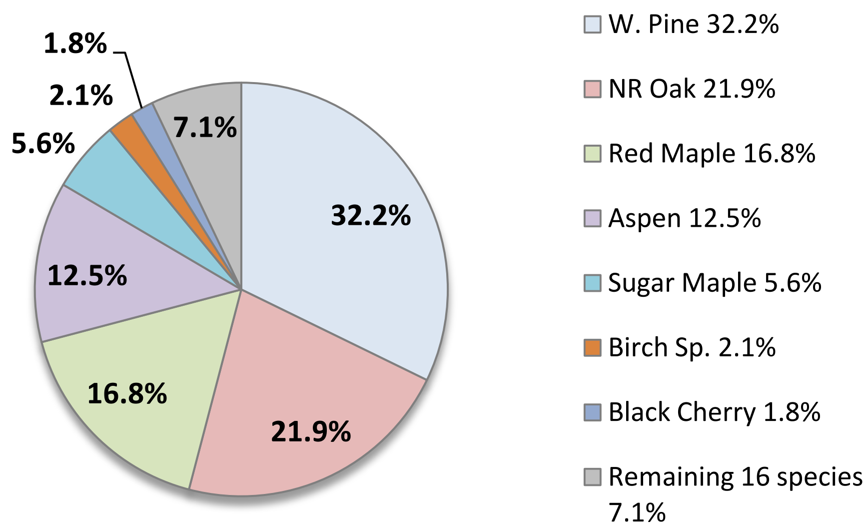


Figure 3-3. Unitil-NH System species mix by percent of total tree population.

Table 3-3. The Most Common Tree Species Found on the Unitil NH Distribution System in Order of Frequency

Common Name	***Scientific Name***
--------------------------------------*Deciduous Species: 65 Percent*------------------------------	
northern red oak	*Quercus rubra*
red maple	*Acer rubrum*
aspen	*Populus spp.*
sugar maple	*Acer saccharum*
birch	*Betula spp.*
black cherry	*Prunus serotina*
white oak	*Quercus alba*
American elm	*Ulmus americanna*
ash	*Fraxinus spp.*
American beech	*Fagus grandifolia*
Norway maple	*Acer platanoides*
silver maple	*Acer saccharinum*
Siberian elm	*Ulmus pumila*
pin oak	*Quercus palustris*
hawthorn	*Crataegus spp.*
apple	*Malus spp.*
--------------------------------------*Coniferous Species: 35 Percent*------------------------------	
white pine	*Pinus strobus*
Norway spruce	*Picea abies*
pitch pine	*Pinus rigida*
eastern red cedar	*Juniperus virginiana*
eastern hemlock	*Tsuga canadensis*
red pine	*Pinus resinosa*
blue spruce	*Picea pungens*

3.2.3 Tree Removal

Trees can be managed by pruning or complete removal. As part of the workload survey, trees were identified by ECI as removal candidates when their growth characteristics or conditions indicated a need, or because their location suggested the potential for cost-effective removal. Candidates typically included volunteer trees (brush that has been allowed to mature) and trees that were dead, dying, diseased or otherwise structurally unsound (hazard trees). In general, trees in landscaped areas and other ornamentals were usually not classified as removals unless the tree was located directly underneath the conductors, or it was felt that removal would be especially beneficial (e.g., trees that have been improperly trimmed in the past, fast-growing trees with minimal clearance, trees with major structural defects, or immature trees that, when mature, will require repeated pruning to maintain an acceptable clearance).

It is estimated that 20 percent or more of the Unitil-NH tree workload could be removed (hazard trees + removals). Figure 3-4 presents data obtained from a typical utility, and provides a comparison of the cost to remove a tree compared to that of pruning it. For most utilities, it costs no more to remove smaller trees than it does to prune them. In fact, many small trees can be removed for less than it would cost to prune them, resulting in reduced short-term expenditures.

Figure 3-4. Comparison of Relative Pruning and Removal Costs.

Figure 3-4 also illustrates that the cost to remove a tree significantly increases as the size of the tree increases. Guidelines help assure that the selection of trees to be removed is cost effective. However, since removal and stump treatment of deciduous trees will reduce the future workload and provide for long-term cost reductions, many utilities are often willing to remove some larger trees. However, generally it is not cost effective to invest more than three times the pruning cost to remove a tree. Otherwise, removal is usually cost effective and should be pursued. Following a present value analysis of the cost of tree removal versus periodic pruning, some utilities find that it is only economical to remove trees with no more than a 2 to 1 ratio. It should be noted that removal of trees clearly identified as hazardous (dead, or exhibiting characteristics indicating predisposition to structural failure with the potential to strike primary lines) is often warranted – even at higher cost. It was noted during the ECI audit that removal of obvious hazardous trees and small trees growing under conductors has been a part of Unitil-NH's practice, mainly apparent on multi-phase circuits at 13.8kV and above.

3.2.4 Tree Pruning

Even with an aggressive removal program, most of the trees on the distribution system will remain, therefore requiring periodic pruning.

The following is a break-down of the vegetation management workload[6] at Unitil-NH:

- Approximately 67 percent of the total trees require side-trimming (growing adjacent to or beside the ROW).
- Approximately 12 percent of the total trees require top-pruning (growing under the conductors).
- Approximately 20 percent of the total trees can be considered hazard trees
- Of the total population, approximately 6 percent of the trees have large overhanging limbs.
- On the Unitil-NH system, 12 percent of the spans surveyed required no vegetation management.

Pruning is a temporary measure, but the use of proper techniques can reduce and direct growth away from the conductors, providing adequate clearance for a longer time. Improper trimming techniques can stimulate growth, thus providing only short-term results. Studies have shown that properly pruned trees encroach on the conductors at a rate that is 25 percent to 50 percent slower than improperly trimmed trees. ECI observed that Unitil-NH's contract line clearance crews are following proper arboricultural standards.

3.2.5 Clearance

As part of the workload study, average distance to the conductors was recorded for individual trees that were identified as requiring maintenance. Figure 3-5 shows Unitil-NH tree population by clearance proximity to the overhead conductors. Across the system, approximately 13 percent of the tree workload is within 2 feet of the conductors and approximately 38 percent within 5 feet of conductors and capable of making contact by the end of the 2010 growing season. Figure 3-6 presents comparative industry data.

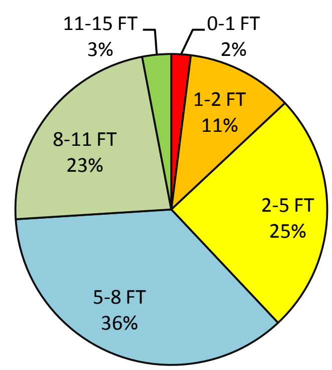


Figure 3-5. Percent of Total Tree Population by Clearance to Conductors.

[6] See Appendix 5.10 for Glossary of Terms.

Tree-to-Line
Contact Percent

Figure 3-6. Tree Contact with Primary Conductors at Unitil-NH 2010 compared to 80 other Utilities in North America.

Table 3-4 shows the Unitil-NH guideline for minimum specified clearance distances between trees and conductors for 4 and 13.8 kV lines.

Table 3-4. Unitil Energy Service Corp. Clearance Guidelines.

	Multi-Phase	*Single Phase*
Clearance above primary conductor	15 foot minimum plus danger trees and dead wood	6 foot minimum above plus danger trees and deadwood
Clearance adjacent to primary conductor	8 foot minimum plus 20 foot minimum clearance for danger trees and deadwood	6 foot minimum plus 20 foot minimum clearance for danger trees and deadwood
Clearance below lowest attachment point on pole	Ground cut or the greater of four (4) foot below lowest telephone cable or 10 foot below primary conductors/open wire secondaries	Ground cut or the greater of four (4) foot below lowest telephone cable or 10 foot below primary conductors/open wire secondaries

When high numbers of trees are capable of contact with the conductors, they may present a threat to the integrity of the distribution system. The National Electric Safety Code (NESC – C2-2002) Section 218[7] states, "Trees that may interfere with ungrounded supply conductors should be trimmed or removed." The 2007 modifications to Section 218 changed the word

[7] The appendix contains the full text of the modified Section 218.

"interfere" to "damage." Section 218 does not specifically state that clearance between vegetation and energized lines should be maintained. Moreover, the industry has not interpreted this rule to mean that mandatory clearances between vegetation and energized conductors be maintained at all times.

Many utilities in North America consider 10 percent tree contact with the conductors to be a reasonable goal for their distribution line clearance program in order to minimize the potential threat of interference with conductors. Many utilities exceed this level of tree-line contact. It is important to note that the detailed conditions associated with trees in contact with conductors are key determinants of the impact of those contacts on system performance. ECI research has documented the importance of construction type, voltage stress gradient, stem diameter and tree species as they relate to a tree branch becoming a fault pathway leading to a sustained interruption. ECI observed a high level of contact on 4kV single-phase lines and taps (Figure 3-7). Normally these conditions and incidental contact between a small tree branch and a conductor normally remain high impedance faults. As previously stated, ECI found that 13 percent of the trees are within five feet or less of the conductors and based on clearance at time of pruning and species growth rates in New Hampshire, approximately 30 percent could be in contact with overhead electrical conductors on the Unitil-NH system by the end of the 2010 growing season. Unitil-NH's ratio of tree caused interruptions between single-phase and multi-phase is 40.7 and 54.7 per 100 miles respectively (Figure 3-18). The combined single/multi-phase rate of 45.1 is significantly higher than most utilities (Figure 3-15). The conditions as illustrated in Figure 3-7 would be best addressed (removed and treated with herbicide) during previous cycles when still brush and small trees.

Figure 3-7. Incidental tree branch contact on single-phase line, Unitil-NH.

Of more concern than incidental contact rates are locations where trees have begun to overhang conductors and could become a conductive bridge between phases, leading to high current, low impedance faults. Trees that have grown over the top of multi-phase lines are examples (Figure 3-8) of higher risks to system performance than incidental contact. While this only represents 7 percent of the tree trimming population on the Unitil-NH system, it is a condition that should be addressed when encountered. Because overhang represents such a small percentage of the overall population, it is ECI's opinion that a change in clearance specifications mandating "ground to sky" clearance across the system is *not* necessary. As 7 percent represents approximately 9,052 trees with major overhang, this can be handled on a case by case basis and efforts be limited to specific areas where failure of overhanging branches has been problematic (either due to construction, tree species or both).

Figure 3-8. Examples of Mature Tree Overhanging Unitil-NH 3-Phase Line – High Risk.

At this point, it is important to note that trees are dynamic and the proximal relationship between the total tree workload and overhead distribution facilities is influenced by several factors. The rate of growth of individual tree species, the amount of clearance achieved at the time of pruning, and work scheduling practices all result in a tree population with varying amounts of clearance at any given time.

3.2.6 Brush Workload - Distribution

DISTRIBUTION

Figure 3-9[8] illustrates that the distribution brush workload on the Unitil-NH system falls in the low and medium Density[9] and Height[10] classes. Approximately 61 percent of the brush is in the 0 to 6-foot height class, with 39 percent being in the 6 to 12-foot class. Unitil NH has not utilized herbicides to control brush on the distribution system. Rather, trees and brush are either hand cut or mowed and allowed to re-sprout. (See Figures 3-10 and 3-11).

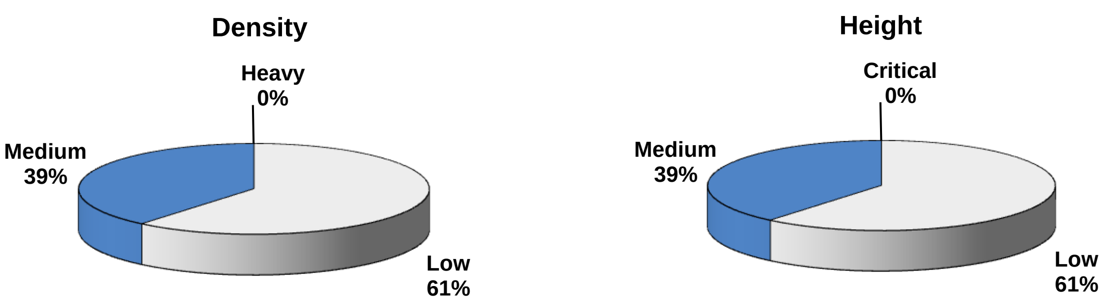


Figure 3-9. Brush Workload on the Unitil NH Distribution System Divided into Density and Height Classes Reported in Percent of Acres.

[8] The percentage for density and height are the same. Brush represented .089 acres/mile or 93 total acres on distribution and there was little variation in brush on distribution.

[9] Density: Low = 0 to 35% cover (<5,000 stems per acre) Medium = 35 to 70% cover (5k to 10,000 stems per acre) High = 70 to 100% cover (>10,000 stems per acre)

[10] Height: Low = 0 to 6 foot Medium = 6 to 12 foot High = 12 to 18 foot Critical = over 18 foot

Figure 3-10. Example of Brush on the Unitil-NH System Cut Five Years Earlier that Grew to Conductor Height.

Figure 3-11. Example of Trees/Brush Cut One Year Earlier without Herbicide Treatment (note the numerous sprouts re-growing from each un-treated stump). This example is on a Unitil-NH Sub-Transmission Line.

As brush height increases, the practicality of herbicide use to control brush with foliar herbicides in rural areas decreases. In addition, the cost of control increases, and the difficulty in attaining permission to remove brush increases. Herbicides can be used to control stump sprouts from any sized tree. Failure to routinely address the current brush workload could result in the addition of nearly 573,800[11] trees (a 455-percent increase) to the permanent workload. Through the selective use of herbicides, ECI estimates that the current brush workload could be reduced by over 60 percent.

[11] Potential tree in-growth: calculated by taking percent of total brush acres of each density class X stems per acre in each respective density class.

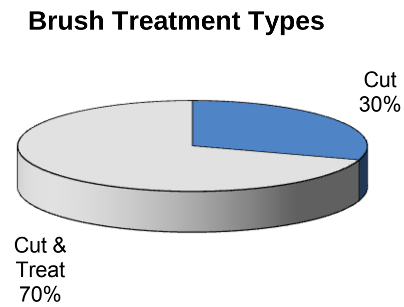


Figure 3-12. Percent of Total Brush Acres by Treatment Type.

Projected current brush acreage by treatment type is presented in Figure 3-12. Treatment types included hand cutting (Cut) and hand cutting followed by herbicide application to the stump (Cut and Treat). Current Unitil-NH practices do not include the treatment of cut stumps. Process changes and corporate policy adjustments, should be considered to include stump treatment of hand cut brush and trees. This is an industry best practice.

3.2.7 Growth Data

One of the primary factors in determining the appropriate maintenance cycle for the Unitil-NH distribution system is the rate at which the trees grow after being pruned. ECI completed a detailed study of the regrowth rates for the most commonly occurring tree species on the distribution system. Sample sprouts were collected from these previously pruned trees at various locations throughout the Unitil-NH system. The most common tree species were selected for regrowth measurement. Sample sprouts were measured to determine the amount of growth per year, as well as the total growth since the last trim year. Using data from these samples, an overall picture of growth rates throughout the Unitil-NH system for the past six years can be observed (Figure 3-13).

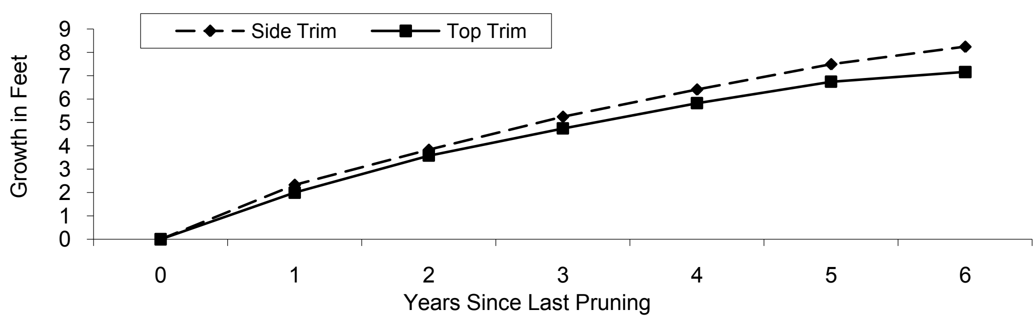


Figure 3-13. Mean Growth Rates of Top- and Side-Pruned Trees on the Unitil-NH Distribution System.

Growth rates will fluctuate based on abnormalities in the growing season, and there will be trees that grow both faster and slower than average. Figure 3-14 illustrates the mean and standard deviations for the three faster-growing trees common to the system. Top growth was not included as there were an inadequate number of top trims on the system (17 percent) to provide a meaningful statistical comparison. These three species represent approximately 51 percent of Unitil-NH's total tree population. The three species are Red Maple (Acer rubrum); Aspen (Populus Spp.); and Northern Red Oak (Quercus rubra). Of special note is Red Maple. The mean regrowth rate in five years is 10.8 feet. Maximum growth rate noted for individual Red Maples approached 14 feet of re-growth over the five year period. Consideration should be given to a focused removal effort directed toward Red Maple growing to the side of the conductors or to establishing enhanced clearances standards for this tree species.

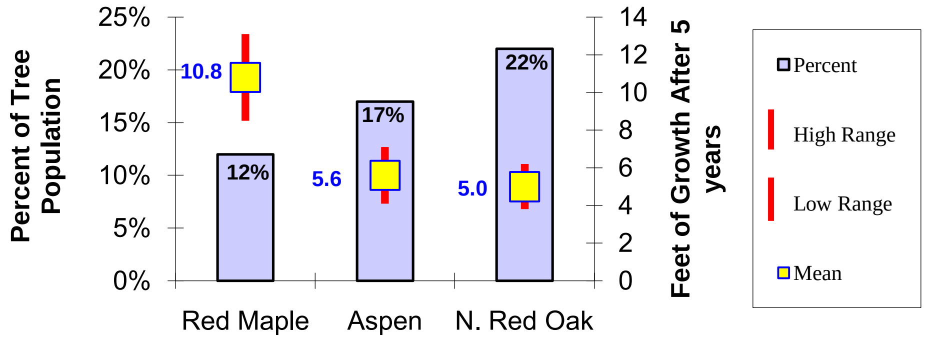


Figure 3-14. Measured Mean Side Growth with Standard Deviations Illustrated after Five Years for Three Tree Species on the Unitil NH System, Representing 51 Percent of the Total Tree Population.

3.3 Sub-Transmission System Workload

The sub-transmission on Unitil-NH system consists of 110 overhead miles of 34.5 kV (63 miles in Capital Region and 47 miles in Seacoast Region). The 34.5 kV sub-transmission systems represent nine percent of the total overhead system miles. The sub-transmission system is addressed separately in this report as the characteristics of this system, as well as the vegetation maintenance requirements, are wholly different than those of the distribution system. The majority of the 34.5 kV lines are on rights-of-way that average forty to fifty feet in width. In addition, approximately 90-percent of these ROW are off-road. The required trimming is primarily side-trimming (99 percent) on both sides of the ROW. However, these trees are at the edge of the established ROW and side-growth from these edge trees does not present a major pruning maintenance concern. Of greater concern are the hazard and danger trees along the edges of the ROW. Top trimming is generally limited to trees in residential/park settings. The floor of the ROW has received cyclic brush mowing or hand cutting where terrain and ground conditions preclude mechanical clearing. Currently there are 2.6 acres of mowing per mile of ROW. The use of herbicides has not been a part of the maintenance practices in over ten years. This is due to the lack of Unitil staff to pursue the legal notification requirements of New Hampshire and to meet with concerned land owners and municipal officials.

SUB-TRANSMISSION BRUSH CONTROL

ECI did not conduct a brush analysis of the sub-transmission system. Sample points were taken for side tree evaluation and observations made regarding the sub-transmission ROW floor maintenance. Unitil-NH has been maintaining the sub-transmission system for numerous years via mechanical mowing and hand cutting. The current maintenance practices have been adequate to prevent ROW brush from growing to a height to cause interruptions to the sub-transmission system. The work has been conducted on a unit-price basis ($/acre) and the system is relatively clear of taller brush. However, the lack of herbicide treatment has caused the stem count per acre to accelerate (see Figure 3-10) thus increasing the sub-transmission future workload. The appropriate use of herbicides and the introduction of Integrated Vegetation Management (IVM) practices will reduce the tall growing trees per acres and future workload, thus reducing future ROW maintenance costs.

The width of the ROW precludes the need for widespread side-trimming. However, there should be a program of hazard and danger tree identification and mitigations established. The brush mowing is contracted using lump-sum contracts based on the acres to be maintained. The minimal amount of trimming that is required is handled by sharing the distribution line clearance hourly crews.

3.4 Tree-Related Interruptions

Trees are a leading cause of service interruptions at Unitil-NH and at most utilities. One useful means of comparing effectiveness of vegetation management programs is on the basis of tree-related outages per 100 miles. Figure 3-15 compares Unitil-NH's tree-caused outage frequency to various benchmark indices for primary voltages. Unitil-NH reported an average of 45 tree-related outages per 100 miles for the years 2007-2009[12] (Figure 3-15). This number is more than five times the national norms. This benchmark is somewhat limited, however, since it does not normalize for exposure associated with tree density.

Tree-related Interruptions per 100 mile

Figure 3-15. The Average Number of Tree-Related Primary Outages per 100 Miles for 2007-2009, as Compared to Levels Seen Elsewhere in the Industry in Nation-Wide Benchmarks.

A common reliability index also points to relatively high tree-related interruptions. Figure 3-16 summarizes Tree SAIFI for Unitil-NH, and a large benchmark group of utilities.

Figure 3-16. Unitil-NH 2007-2009 Average Tree Related SAIFI, Excluding Storms, Compared to Nation-wide Utility Benchmarks.[13]

Another common metric used to assess the effectiveness of a distribution line clearance program is primary interruptions per 1,000 trees. The primary tree-related interruptions per 1,000 trees metric relates more directly to outage exposure than does the outages per 100

[12] Represents the number of interruptions due to vegetation and not normalized by duration of outage.
[13] Based on ECI analysis of Unitil-NH outage data .

miles metric. Figure 3-17 presents Unitil-NH's reported interruption annual average between 2007 and 2009 per 1,000 trees based on ECI's projection of tree workload on the primary distribution system. Unitil-NH's tree-caused interruptions per 1,000 trees are higher than many others in the industry.

The multi-phase portion of the Unitil-NH system is more prone to tree-caused interruption events than the single-phase portion of the system. Interruptions per 100 miles and per 1,000 trees are higher on multi-phase circuits than on single-phase lines (Figure 3-18). Figure 3-19 and figure 3-20 show the break down for Unitil–NH Seacoast and Capital Regions, respectively.

Figure 3-17. Data showing that the number of tree-related outages per 1,000 trees is well above what is typically found in the industry.

Figure 3-18. Unitil-NH-System: Mean Three-year (2007-2009) Non-storm Outage Frequency per 100 Miles and per 1,000 trees for Single-phase and Multi-phase Standard Maintenance Circuits.

Figure 3-19. Unitil-NH-Seacoast: Mean Three-year (2007-2009) Non-storm Outage Frequency per 100 Miles and per 1,000 trees for Single-phase and Multi-phase Standard Maintenance Circuits.

Figure 3-20. Unitil-NH-Capital: Mean Three-year (2007-2009) Non-storm Outage Frequency per 100 Miles and per 1,000 trees for Single-phase and Multi-phase Standard Maintenance Circuits.

Figures 3-21 provides an estimated tree contact exposure each year after initial pruning (year 0). It is useful in understanding how the selected trim cycle and species growth rates will affect the vegetation workload on the Unitil-NH system. This is based on the current Unitil-NH clearance specification for side trimming of 8-foot.

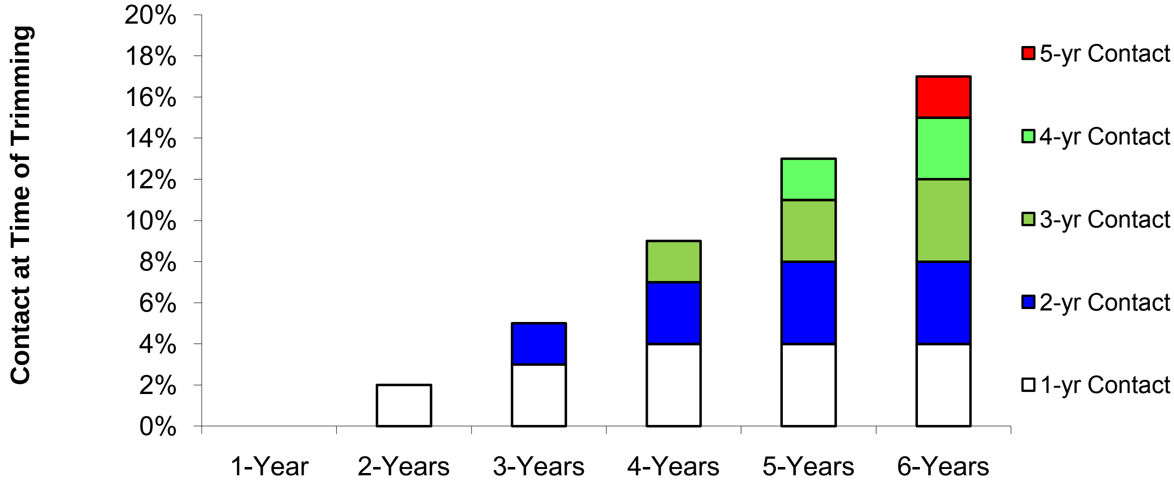


Figure 3-21. Projected Tree Contact by year since pruning with 8 foot side clearance.

Per Figure 3-21 above: 1-year cycle = 0 percent contact; 2-year cycle = 2 percent contact; 3-year cycle = 5 percent contact; 4-year cycle = 9 percent contact; 5-year cycle = 13 percent contact; and a 6-year cycle = 17 percent vegetation contact. This is based on growth rate data by predominant species collected by ECI and run thought ECI's Growth Simulator Model.

Table 3-5 shows the percent of vegetation clearance for the distribution system as it existed in April 2010 during ECI's survey. The clearance to conductors is for various clearance ranges measured.

Table 3-5. Tree Population Clearance to Conductor.

Clearance	0-1ft	1-2ft	2-5ft	5-8ft	8-11ft	11-15ft	*TOTAL*
Percent	2%	11%	25%	36%	23%	3%	100%

The data in Table 3-5 shows that Unitil-NH has approximately 13 percent of their total trees on the system with two-feet or less of clearance.

An in-depth analysis of Unitil-NH vegetation-caused interruptions across the system shows that approximately 43 percent are caused by broken limbs, broken/split trunks or up-rooted trees. While the interruption cause codes do not in all cases, accurately classify these outages, the troublemen responding to the interruptions record details on the types/causes of interruptions. Frequent pruning, in and of itself, may not significantly impact these types of interruptions. Hazard tree assessment and removal must be incorporated into the Unitil-NH program to ensure expected reliability improvement.

3.5 Expenditure History and Production

3.5.1 Program Expenditures

Scheduled work is far more efficient than non-scheduled work in terms of cost versus benefit. Non-scheduled, reactive maintenance often has minimal impact on reliability, and frequently costs two to five times more per unit than does scheduled work. However, a certain base level is necessary. Unitil-NH incurred an expenditure of $54,000[14] for unscheduled work in 2009. This equates to 7.5 percent of Unitil-NH's total maintenance budget. In comparison, even the best performing utilities benchmarked operate near five percent. Figure 3-22 shows the historical Unitil-NH line clearance expenditures.

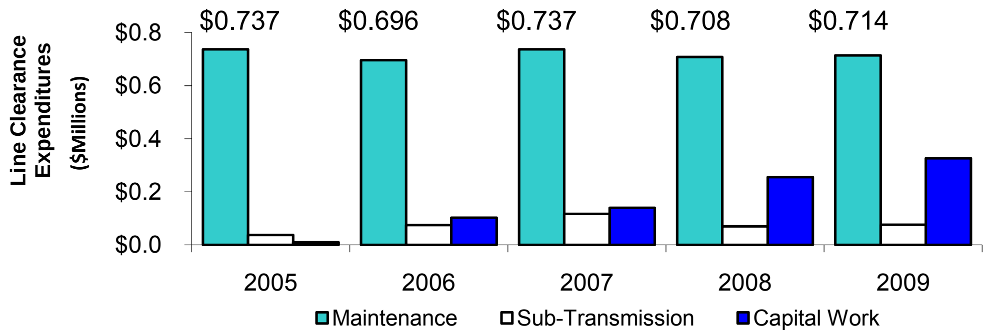


Figure 3-22. Unitil-NH's Historic Distribution Vegetation Management Program Expenditures.

3.5.2 Production

Unitil-NH 2009 contractor vegetation maintenance cost was approximately $714,234 to prune 90.33 miles of cyclic maintenance work. These 90.33 miles represents only spans requiring pruning (work spans), not total spans or circuit miles covered. To compare Unitil-NH to an ECI benchmark group, Unitil-NH's "total miles covered" for 2009 would be 101.18 miles based on a estimate of 12 percent open spans not requiring pruning (from ECI survey) or $7,059 (normalized) per mile.

Figure 3-23 compares Unitil-NH's cost per mile with several benchmark utilities. The data in both figures has been normalized for variation in contractor and equipment billing rates, and is expressed in 2009 dollars. Unitil-NH's total maintenance costs are relatively high. Unitil-NH cost includes the work area protection which can average up to 50 percent of the contractor maintenance cost. Work area protection by off-duty police officers is mandated by local ordinance in the majority of the 30 municipalities served by Unitil-NH.

[14] Source: March, 2010 UES Distribution Vegetation Control Cost Report. Ray Letourneau. Assumption Cost based on average cost per unit (span) of unscheduled work as reported in the first quarter 2010.

As shown in Figure 3-23, Unitil–NH is among the highest in the group in terms of cost per mile. Factors that are likely to be major contributors to the relatively high cost-per-mile compared to the benchmark group: (1) Work area protection cost, the charge by local municipalities to provide police for work area protection as mandated, (2) Urban nature of the Unitil-NH service territory, (3) System tree density, and (4) Unitil-NH cyclic maintenance deficit (deferred work).

<u>Work Area Protection:</u> A majority of the 30 local municipalities within the Unitil-NH service territory have local regulations requiring Unitil-NH to utilize the local police force to provide work area protection anytime a crew is working along a public road-way. The majority of the Unitil-NH system falls into this category. This cost accounts for approximately 30 to 50 percent of the Unitil-NH vegetation cost. The presence of local police for work area protection does not preclude the line clearance contractor from putting out signs/cones etc. for work area protection as well. This added cost has a significant impact on the cost per mile without contributing to increased production (more miles covered or more trees pruned). As demonstrated in Figure 3-23, the addition of work area protection cost pushes Unitil-NH's cost per mile for line clearance work to among the highest in the nation.

<u>Urban Maintenance:</u> Most of Unitil-NH's circuits can be categorized as urban in nature. This precludes the opportunity for significant efficiencies as higher customers per mile

[15] Unitil-NH as supplied by Ray Letourneau, Jr.

[16] Data from participants in an ECI benchmark group of U.S. electric utilities together with Unitil Energy Services. Cost per mile was adjusted to reflect differences in local labor and equipment billing rates and adjusted with CPI (Consumer Price Index) conversion factors to 2009 dollars. The Benchmark group represents circuit miles completed, not just actual miles trimmed. Unitil tracks production by units or spans (175-ft. /span) of actual work completed. The Unitil-NH calculated $/MI mile was adjusted to reflect the approximately 12 % open spans not requiring work for comparison to the Benchmark group of utilities. Unitil cost also includes the expense paid to local municipalities for Work Area Protection (approximately 50% cost added to contract trimming cost).

of line requiring more customer interaction. Opportunities for leaving cut limbs or debris on the work site are limited in urban settings. Through benchmark studies, ECI has found loping and scattering on site to be 36 percent more cost effective than chipping and hauling.

System Tree Density: Unitil-NH has a high tree density at 154 trees per mile. This is just under the average for New England at 157 trees per mile. The northeast has some of the highest tree densities in the United States, which contributes to more trees per mile requiring pruning than other areas of the country. In addition, ECI found that approximately 12 percent of the system has open spans that do not require vegetation maintenance. The high tree count per mile and the lack of open spans contributes to a very heavy workload per mile of overhead line.

Behind on cycle: Unitil-NH has established cyclic pruning goals based on multi-phase/single-phase construction and by voltage. Using the Unitil-NH cyclic goals, approximately 150 miles per year should receive pruning. In 2009, approximately 102 miles received cyclic pruning. This was only 68 percent of the annual pruning goal or 32 percent behind on cyclic pruning for 2009. The high tree density (tree/mile) in combination with being behind on cyclic pruning has resulted in heavier pruning requirements. Vegetation growing in close proximity to the conductors requires the line clearance crews to exercise greater caution for their personal safety and to prevent un-planned outages. It has been ECI's experience that utilities that maintain their system on cycles based on the growing conditions maintain higher crew productivity.

As seen in Figure 3-24, the unit production by the current line clearance contractor is better than the average of the 13 utility benchmark groups. Utilizing the Unitil-NH production as recorded during April, 2010. A weighted average of 0.68 man-hours per tree was calculated. This weighted average man-hour per tree was calculated using percent of top trims and side trims for both on and off-road situations and processed by ECI's **TRES**© program.

Figure 3-24. Man-hour per tree trimmed, Unitil-NH compared to benchmark utility group.

3.5.3 Annual Maintenance Cost Comparison

Figure 3-25 illustrates the relative cost of vegetation maintenance operations at Unitil-NH together with the key reliability metrics, compared to other utilities. Costs include the multi-year average cost for both preventive and corrective vegetation maintenance, normalized for differences in tree density, local tree crew billing rates (cost of flagging/work area protection was included for Unitil-NH) and relative accessibility of vegetation to aerial lift equipment.

Unitil-NH’s normalized cost per mile per year (annual expenditure divided by total line miles) was among the lowest in the group of 12 utilities. However, the effectiveness of the maintenance expenditure was also among the lowest.

Unitil Energy Systems – New Hampshire

Section 4:

CONTENTS

Unitil Energy Systems- New Hampshire

4.0 Recommendations

4.1 Overview

4.1.1 General Assessment

ECI evaluated Unitil-NH's field conditions, operating procedures and work practices. On the basis of this evaluation, our experience evaluating more than 160 other programs, and comparison with other utilities and benchmark groups, it is evident that Unitil-NH has, over the last three years, established many attributes of a good distribution vegetation management program. Observations leading to this conclusion include the following:

- Unitil Field Supervisors who are knowledgeable regarding the Unitil-NH electrical system are in place devoting approximately one third of their time to vegetation management. They have a good understanding of the components necessary for effective implementation of a vegetation management program.
- Work practices and operating procedures are fairly standard, providing for technically correct pruning practices.
- Unitil-NH devotes minimal resources to maintenance of trees growing near service lines and focuses resources on planned maintenance actives to maximize system reliability improvements.
- Unitil has periodically applied enhanced line clearance targeting a specific problem/ location on the system. This has been effective in resolving reliability issues on circuits with extremely poor reliability performance. However, this has not improved overall system reliability.
- Scheduling is predominantly cyclic, however, adjustments are made in actual schedule within a year and between years based on reliability and cursory evaluation of pending work.
- Contract methodology is being revised to some degree to better control cost while achieving maximum clearance and contractor productivity.

ECI concludes that Unitil-NH has established a program where many positive elements can be identified. The focus of standard maintenance to provide clearance between trees and conductors has not been effective in addressing the primary cause of tree-related interruptions, which is mechanical failures of trees and branches that fall onto lines.

ECI's assessment leads to 14 overarching recommendations:

1. Begin to maintain single-phase 4kV lines on a shorter cycle emphasizing the removal of more trees (from 10-year to 7-year cycle).
2. Begin to maintain 13.8kV multi-phase lines on a shorter cycle emphasizing the removal of more trees (from 5-year to 4-year cycle).
3. Implement a mid-cycle program for multi-phase lines to prune the “cycle-buster” trees that will grow into the conductors prior to the next cyclic pruning. Include a

mid-cycle inspection of single-phase circuits and provide clearance at poles containing critical equipment (transformers, etc.).

4. Implement an enhance clearance standard for Red Maple. Based on the rapid re-growth rate of this species greater clearance at the time of maintenance will help extend the average cycle length.
5. Consider increasing side clearance from 8-feet to 10-feet, this will provide for a 5-year cycle vs. a 4-year cycle (as determined by species re-growth on the Unitil-NH system).
6. Establish a hazard tree identification and mitigation strategy. Hazard and danger trees contribute significantly to Unitil-NH's tree-caused outages. Developing an inspection, rating and prioritized hazard tree removal program will improve the system reliability. Use of a hazard rating system at the time of evaluation and prioritizing based on voltage and number of phases present (highest voltage multi-phase to the single-phase lower voltage areas) will help allocate resources based on risk and benefits. By developing a multi-year expenditure strategy, the initial high cost of removal can be spread over several years.
7. Continue a reduced Reliability Enhancement program focusing on multi-phase circuits. The program should be prioritized based on tree-caused customer interruptions per mile. Field survey/work planning to determine exact scope of vegetation work required should be conducted. Addressing entire circuit not necessary, but efforts should be concentrated in a targeted manner. These circuits should be considered for the current year's cycle, move out circuits with better reliability performance. This practice should continue to be a joint effort with Operations and Reliability Engineering. This process will generate the quickest improvement to system reliability.
8. Establish the position of System Arborist and provide the individual with the authority to implement and oversee the recommended vegetation management program. In addition, assign full-time individuals to the position of Assistant Arborist to assist the System Arborist with the implementation of the vegetation management program and provide QA/QC on contract line clearance work.
9. Begin to utilize herbicides to control stump sprouts and standing brush where appropriate. Apply Integrated Vegetation Management (IVM) principles on the Unitil-NH system, especially the sub-transmission.
10. Expand the newly established mail method of property owner notification to include more personal contact and use of door cards prior to tree removal or heavy pruning.
11. Enhance the record-keeping systems for line clearance in order to maintain comprehensive records of production, and use this enhanced data for program management and to document contractor performance. Switch to miles and trees/brush units worked as measures of contractor performance rather than the current units (spans) being utilized. This is extremely valuable in establishing production and cost standards for specific work units (trees trimmed per man-hour, trimming cost per unit of top or side pruning, tree removal cost based on size class, etc.). Adopt work planning, record keeping and auditing practices that optimize work quality and cost-effectiveness.
12. Establish an ongoing work acceptance process (QA/QC) designed to formally document and confirm work quality and work completion to established standards,

such as: compliance with clearance standards; appropriate and targeted tree removals; and effective application of herbicide. Establish a ratio of crews to supervision that is appropriate for the number of production resources utilized.

13. Begin to conduct tree-related interruption autopsies to provide data regarding specific characteristics of trees that fail, and use that data to better target the enhanced maintenance program toward that portion of the tree population that is most prone to fail and cause outages. This includes enhanced/expanded vegetation outage record keeping to provide more details on types of tree outages (i.e. growth, broken limb, broken trunk, up-rooted tree) as well a location of the tree that caused the outage (on or off the ROW).
14. Following adoption of an appropriate maintenance strategy, consistently fund the program accordingly.

The recommendations in the following section identify specific strategies for creating a more effective vegetation management program.

4.1.2 Scope of Recommendations

The assessment covered a wide range of subjects relative to the vegetation management program. The results of the assessment segregate the program elements into the following categories, each appropriately treated in this section.

A. Elements of Unitil-NH's program that were found to be consistent with those of best practice utilities. Little or no further discussion of these items is required in this section. Elements in this category include:

- Crew headquarters and dispatch
- Debris disposal
- Customer relations

B. Elements of the program where minor comment is appropriate. These elements all fall under the general category of Work Practices (Section 4.2) and are as follows:

- Contract specifications and work standards (Section 4.2.1)
- Tree pruning and removal (Sections 4.2.2 and 4.2.3)

C. Elements of the program which receive considerable discussion, and which require significant recommendations for change. These elements include:

- Brush control and use of herbicides (Section 4.2.4)
- Hazard tree removal (Section 4.2.5)
- Program management, supervision and work planning (Section 4.3)
- Production data collection and reporting (Section 4.5)
- Maintenance strategies and cost projection, including scheduling alternatives, benefits and cost (Section 4.6)
- Evaluation of productivity and work quality/auditing (Section 4.2.2)

4.2 Work Practices

4.2.1 Specifications and Standards

Unitil-NH Distribution Line Clearance Specifications (#OP5.00) establish technical expectations for tree pruning, tree removal, the treatment of cut stumps to prevent sprouting and proper site cleanup. One major consideration conspicuously absent in the specification is any referral to following accepted arboricultural practices for utility pruning. This specification should reference American National Standards Institute (ANSI) A-300 standards for tree pruning. Appendix 5-9 contains ECI's recommended revised standard document.

Clearances

Specific standards in feet of clearance to be achieved at the time of maintenance are included in the Specification and are within the range that many effective line clearance programs are able to achieve. While 8 feet of horizontal (side pruning) clearance is often adequate, Unitil-NH should strive for greater clearances for fast-growing species on the Unitil-NH system (see discussion under Pruning). ECI observed many instances where considerably more than the 8 feet of specified side clearance has been achieved, especially on three-phase along major highways. The specifications appropriately emphasize maintenance of primary lines as opposed to services. If Unitil-NH moves from 8-foot side clearance standard to a 10-foot side clearance standard, the cycle length could be extended one year.[1]

Tree Removal

Specifications generally only address danger tree removal. The specification should include guidance for removal of all tall-growing tree species within the right-of-way (growing directly under overhead conductors), along with stump treatment to prevent re-sprouting. Where implemented, this practice will help maintain low costs by eliminating these "trapped" trees and removing them from future pruning consideration thereby contributing to reliable, cost effective service. Trees that should be targeted for removal are those that pose the greatest risk to safety, system reliability and storm hardness. Efforts should be directed at three-phase 34.5 and 13.8 kV lines to maximize reliability improvement for dollar expended. These trees are defined as:

- Healthy trees growing directly below overhead lines ("trapped trees").
- Healthy trees with trunks established within 10 feet of the overhead lines, especially when they are growing at pole locations.
- Healthy trees with branches that have the potential to grow within 3 feet of the line.
- Hazard trees (or parts thereof) that are at high risk and are within falling distance of the lines.

The current specification interchanges the definition of danger and hazard trees. In the utility vegetation management industry, these terms have unique meanings. A danger tree is any tree that upon falling would come in contact with the electrical conductors. A hazard tree is any tree that upon falling would come in contact with the electrical conductors *and* these

[1] At the current 8-foot clearance, in 4-years 9% of the trees would be in contact with the conductors; at 10- foot of clearance, in 4-years 4percent of the trees would be in contact with the conductors.

trees are predisposed to failure due to: significant lean; structural defects (cracks, weak crotches, extensive damage to bark or root system); presence of decaying organisms; or excessive dead wood in the top. By adopting a process of identifying and rating hazard trees, and vigorously pursuing removal, a significant number of outages due to these hazard tree failures can be eliminated.

New Hampshire requires prior property owner permission for utility pruning/removal. At the beginning of 2010, Unitil-NH instituted a new method of notification wherein all property owners on a circuit scheduled for pruning receive notification via US mail. It then becomes the property owner's obligation to notify Unitil-NH if they take exception to the utility pruning. As this is a newly instituted program, ECI is not sure what volume of follow-up will be required by this significant change in notification / permission process. It also remains to be determined if New Hampshire will consider this as adequate notification especially if a significant or large number of complaints are received. While this may be sufficient for pruning, it may not be an acceptable practice if herbicides are to be applied to the cut stump or to standing brush.

Unitil-NH's ability to achieve greater clearances or remove certain trees may be restricted by existing easements. Direct contact with property owners when performing enhanced maintenance has helped in the past, and should become a part of the process to address trees located outside prescribed easement widths and for permissioning tree removals.

4.2.2 Tree Pruning

By far, most vegetation is kept clear of power lines through pruning. For the most part, the pruning practices observed throughout Unitil-NH's service territory meet the accepted arboricultural standards for utility line clearance, as described in the American National Standards Institute (ANSI) A-300 tree pruning standard.

Whether or not overhanging limbs are removed when trees are pruned can have a significant impact on reliability. The industry has found that branches overhanging the conductors can be one of the most significant threats to service reliability. This is particularly true in areas subject to snow and ice loading such as New Hampshire, in addition to summer storms. Trees with overhanging limbs represent approximately 7 percent of the trees (approximately 16,200 trees) on the Unitil - NH system. Unitil-NH should emphasize removal of all overhanging limbs above sub-transmission and 34.5kV distribution multi-phases lines. However, ECI is not recommending that all overhanging limbs on multi-phase 13.8kV or 4kV lines be implemented. ECI is recommending a more refined approach where overhang on weak-wooded species be removed as well as overhang on White Pine. A whole-sale approach of removing all overhanging limbs to reduce the risk of broken limbs falling on or across conductors will prove very expensive and meet with resistance from Unitil's customers and may only provide marginal improvement is system reliability. ECI strongly suggests that Unitil-NH continue the reliability enhancement evaluation of circuits where-by problematic circuits (a high number of tree-cause interruptions that affect a large customer load) are investigated as to the causes and determine if enhance pruning and tree removal, electrical infrastructure or a combination of both should be addressed to improve circuit reliability. However, rather than performing spot trimming on these circuits, move the entire circuit into the current year's maintenance program. Prior to assigning these circuits to contract crews, a thorough evaluation should be made of current vegetation conditions to determine if and what type of enhanced pruning/removal practices should be implemented on these circuits as a part of this enhanced maintenance. This investigation may emphasize the removal of overhanging limbs for specific problematic areas (due to species, tree characteristics, etc.) or hazard tree removals that will result in significant improvement in reliability. Since a thorough review and inventory of the vegetation workload will be conducted (including specific trimming requirements, designating trees for overhang removal, designating hazard trees for removal), these circuits would be excellent candidates for lump sum/ firm priced bidding.

Minimum Clearance

There are three key factors that determine the appropriate pruning cycle for a given area: (1) the characteristics of the tree workload (primarily species composition), (2) local re-growth rates, and (3) the clearance achieved at the time of pruning. Utilities can encourage removal of fast-growing species and trees directly under the lines and can enforce the use of natural pruning techniques to slow the re-growth. Otherwise, they have little control over the first two factors. On the other hand, a utility can significantly influence the clearance obtained at the time of pruning.

Unitil-NH's current maintenance cycles are established based on voltage and construction types (multi-phase / single-phase). Clearance specifications call for 8 feet of side clearance. Measurements made by ECI, along with discussion with field staff and contractors; indicate that there is considerable variation in actual clearance obtained. ECI observed many areas along major highways where significantly more than 8 feet of side clearance was obtained. Customer resistance in some neighborhoods, especially on single-phase lines, has resulted in minimal clearance. Entire fused taps are skipped due to one or more customer refusal. The theory being that the pruning effort is wasted on that fused tap if there are numerous pruning skips. These taps are eventually pruned in whole or in part when the tap section fuses operates. Generally, it was observed that clearance in rural areas is greater than in urban or suburban locations. Many utilities reflect this greater rural clearance in increased cycle lengths for rural areas. However, the minimal number of rural circuits on the Unitil-NH system may not warrant a separate cycle. Based on the characteristics of Unitil-NH's tree workload in each of the two regions and re-growth measurements on the most commonly occurring tree species, it is recommended that Unitil-NH strive for the following minimum clearances:

- Eight feet of clearance on conifers and slow-growing deciduous trees such as oaks.
- Ten to twelve feet of clearance on medium and fast growing deciduous species such as Red Maple, Sugar Maple, Black Locust, Silver Maple and Elm.
- Unitil-NH should continue to strive for a minimum of 15 feet of clearance for branches that overhang conductors.

A recommended minimum pruning clearance guideline should be used to determine whether or not a tree should be pruned. If the existing clearance for a given tree meets or exceeds the minimum specified clearance for that species, then the tree should not receive maintenance at that time. Implementation of this guideline will help reduce the frequency of unnecessary work completed on trees that already have adequate clearance.

These clearances should be considered minimum unless the tree is properly side pruned back to the main trunk or a major branch. Guidelines that allow for closer clearance between conductors and the main trunk of established trees is a reasonable exception.

Establishing the minimum recommended clearance guidelines is both achievable and reasonable. ECI recommendations have generally ranged from 8 to 15 feet, based on previous utility program reviews and growth studies.

A coordinated approach of good public relations, property owner permission/notification, and proper pruning has allowed our past utility clients to achieve and, in many cases, exceed our recommendations. The existence of a professional certified arborist has shown to be beneficial in talking with customer and municipalities regarding utility pruning requirements. Knowledgeable Arborists have been effective in negotiating additional clearances despite easement provisions that do not provide explicit rights to maintain trees outside of easement boundaries. Good communication with property owners regarding the need for tree maintenance often allows utilities to avoid customer conflicts over easement provisions. ECI's recommended clearances and cycle length recommendations, combined with a sound, professionally managed line clearance program, have been accepted by utilities, property owners and public service commissions.

Contract Monitoring

Regardless of the contract type that is being used, a systematic method of work monitoring should be implemented. Monitoring is essential in order to ensure that the line clearance crews are productive and in compliance with established specifications.

Unitil-NH should monitor crews sufficiently to ensure they are working where and when reported, and should perform regular formal audits of work quality and productivity. However, daily or continuous on-site monitoring is not necessary and will probably reduce productivity. Most utilities have found that on-site crew checks 2 to 3 times per week are usually sufficient to ensure that work is being completed productively and in accordance with specifications. The frequency of crew visits and audits can be increased if problems are discovered.

Monitoring should be performed by Unitil-NH supervisory personnel with sufficient technical expertise to ensure that the specifications are adhered to. Monitoring should include regular audits of production figures reported by crews on weekly timesheets. An analysis of time utilization, performance and effectiveness figures generated by the record keeping system for work completed is recommended. Evaluation of the work quality and adherence to arboricultural standards (ANSI A300) should also be periodically conducted.

4.2.3 Tree Removal

Trees growing close to the conductors must be pruned or removed to prevent interference with line reliability. Though proper pruning techniques can inhibit and redirect growth to extend the time between maintenance, pruning is still only a temporary measure. On the other hand, tree removal can provide permanent clearance and eliminate future trunk or limb failures. Removal of trees in conjunction with a selective stump treatment program to inhibit sprouting of deciduous species will provide both short and long-term benefits (see discussion on herbicide use). Unitil-NH’s practice has been to cut trees and brush from below the conductors as part of standard maintenance however, herbicides have not been utilized to inhibit sprout regrowth.

The critical element of cost-effective tree removal is proper tree selection. It is almost always cost-effective to remove small trees (4"-12" diameter), but the economics of removal change quickly as tree size increases (see Figure 3-4). Unitil-NH’s average cost per tree removed (4"-12" diameter- .66 man hrs. /tree or $23.94/tree) is about equal to the cost per tree pruned (.65 man hrs./Tree or $23.57/tree), based on ECI unit production records from the line clearance contractor. Danger tree removal was not part of this production sample, as danger trees removal is part of a separate process. This implies that the average tree selected for removal is small and may include trees that could actually be classified as brush. It is common for utilities that have high numbers of small trees, and that do not target large hazard trees for removal, to report average pruning costs that are about equal to average removal costs. While beneficial to maintain a low cost per tree removed, there is economic justification on a net present value basis to removing some larger trees, even if the cost of removal is somewhat greater than the cost of pruning. Unitil-NH should begin to more carefully document information regarding trees removed in order to assess the extent of this opportunity.

It is recommended that tree removal be maximized based on economic criteria as a part of routine maintenance. As Unitil-NH has such a small amount of potential removals, approximately 1-percent of the total tree population, it is recommended that these removals be a part of the systematic pruning program. Two fast growing species on the Unitil-NH system are red maple and aspen. They represent 16.8% and 12.5% respectively of the total tree population. Working toward a goal removal of these two fast growing species would greatly reduce the population of these tree species under/near Unitil's overhead lines. Based on establishing a tree outage investigation data base (see section 4.2.6), trees that are most prone to breakage may have the greatest long-term benefit on reliability. The current reliability enhanced maintenance program (very few dollars currently allocated to this) at Unitil-NH should continue to address removal of trees predisposed to failure as a result of deteriorating condition. This program can have a significant impact on improving reliability on poor performing circuits and funding should be significantly increased for this program.

4.2.4 Brush Control and Integrated Vegetation Management

Integrated Vegetation Management (IVM) is the process of using biological, chemical, cultural, manual, or mechanical maintenance techniques to control undesirable vegetation. The selection of control options is based on effectiveness, site characteristics, environmental impacts, safety, and economics.

IVM is recognized as an industry best practice, and it is therefore recommended that Unitil-NH adopt this strategy for the maintenance of undesirable brush on its sub-transmission system. In general, manual, mechanical (mowing) and chemical control methods will be the most appropriate brush maintenance operations for the Unitil-NH sub-transmission system.

Brush Control

Hand cutting deciduous brush without applying a follow-up herbicide application to the stump surface will permit the vegetation to re-sprout, thus requiring future maintenance. Trimming brush and/or allowing it to mature results in its becoming a more expensive, and often permanent, part of the workload. Neither of these brush management techniques is cost effective.

ECI recommends that Unitil-NH aggressively ground-line cut brush, but also begin to treat deciduous cut stumps of trees and brush with appropriate herbicides whenever possible. This will prevent future expansion of the distribution workload and future line clearance cost increases.

In the more rural areas, there is opportunity to treat brush less than 6-8 feet tall with either foliar or basal herbicide applications, avoiding hand cutting. Taller standing dead brush can become a source of complaints, and taller brush can be difficult to control with foliar applications without risking exposure to off-target plants.

Herbicide Use

The use of herbicides is essential if Unitil-NH is to maximize the benefits of its sub-transmission brush-mowing program and the distribution tree and brush removal programs. Herbicide use is an important component of an IVM strategy. While included in the Until-NH Policy/specification document **OP5.00**, in practice, herbicides are not currently used at Unitil-NH under any circumstances on the distribution system.

The effectiveness of selective herbicide applications has been well documented through long-term studies on utility rights-of-way in the central and northeastern United States. Results from treatment simulation models developed through these studies project that sites dominated by deciduous species would nearly double in stem density by the end of two cycles if simply cut without a follow-up herbicide application (Figure 4-1). These same sites would be expected to exhibit about a 50 percent reduction in stem density over the same time period if treated with a selective herbicide application. Note that average brush stem density on the Unitil-NH distribution system is around 6,000 per acre (39 percent medium density of 10,000 stems per acre and 61percent low density at 5,000 stems per acre), with the potential to drop to under 1,000 stems per acre over one or two cycles.

At a minimum, herbicide applications should be an integral part of the Unitil-NH sub-transmission program and expanded to the distribution vegetation management program as well. An important consideration is that use of herbicides must be environmentally safe and professionally supervised to maintain public acceptance. Line clearance crews performing herbicide applications should receive proper training in species identification and herbicide application methods. One key Unitil Supervisor (preferable an arborist who is a licensed pesticide applicator in the state of New Hampshire) should be responsible for the implementation of a comprehensive herbicide use policy and for selecting approved herbicides. Professional supervision by the Line Clearance Foremen is essential to ensure safe, effective application on appropriate species and sites. Herbicide application contractors are currently required to be licensed by the state of New Hampshire and retain liability insurance associated with herbicide application. Unitil-NH must require contractors to demonstrate compliance with regulatory rules and frequently inspect operations to assure that contractors are operating safely and professionally.

Figure 4-1. Effectiveness of Herbicides for Control of Brush Over Time

The first step should be the treatment of stumps, whenever possible, with an appropriate registered herbicide following removal of deciduous trees and brush. Selective herbicide applications (e.g., foliar and basal) for the management of communities of deciduous brush species should also be pursued wherever possible.

Herbicide Safety and Risk Assessments

Today's herbicides control resprouting by blocking chemicals needed by plants to convert water, sunlight and nutrients into food for growth. Since these same chemicals are not present in animals and humans, the herbicides are very low in toxicity to people or animals. Without any food, the treated weed trees on the right-of-way wither and decompose. Treated stumps dry out and don't re-sprout.

Herbicides commonly used for stump treatments are U.S. EPA-registered general use products that are commonly available at local garden centers and hardware stores. No special license is required to purchase these products. Prior to registration by the EPA for use, herbicides undergo rigorous testing to assure the public that proper use of these products will not result in adverse risk to human health, wildlife or the environment.

Approved herbicides are safe for humans and the environment and do not cause adverse effects that are unacceptable. In this context, risk assessment is the process by which the likelihood of unacceptable adverse effects from the use of various methods of vegetation management can be determined.

An extensive report prepared by ECI provided the technical basis for and a summary of the risk to human health, wildlife and the environment from the use of 10 herbicides by a New York utility. These herbicide uses included broadcast foliar, selective foliar, basal bark and cut stump applications. This assessment concluded that the margins of safety for herbicide use by the utility that commissioned the assessment were "adequate to assure protection of human health of workers and the general public."

ECI also completed an environmental impact statement resulting in the authorization of herbicides to control right-of-way vegetation in the Allegheny National Forest in Pennsylvania. Subsequent evaluation of herbicide use in the National Forest confirmed safe and effective use of foliar herbicides to control brush on utility right-of-way.

The human health risk assessment methodology used in these reports was the one generally recognized by the scientific community (National Research Council) as necessary to characterize the potential adverse human health effects of chemicals in the environment. It is the same process used in judging the human health risk from cosmetics, food additives, pharmaceuticals, various household chemicals and many other materials.

Herbicide Acceptance by Wildlife Groups

Stump control herbicides are used not only by electric utilities, but also by the Nature Conservancy on projects designed to limit the spread of invasive and non-native trees and shrubs. Under the banner of an organization called Project Habitat®, groups such as the National Wild Turkey Federation, Buckmasters, Butterfly Lovers International and Quail Unlimited have joined together to encourage utilities to implement an "Integrated Vegetation Management" approach to maintaining utility rights-of-way that appropriately utilizes herbicides as a component in the control of right-of-way vegetation. They have recognized that environmental benefits of herbicides, when properly used, outweigh any adverse risk and are far more desirable than the alternatives to herbicide use, such as frequent mowing or hand cutting of undesirable trees.

Significant research has been undertaken over the past 40 years to document the impact of right-of-way herbicide use on the environment, wildlife and management costs. Much of this research has been conducted by ECI and its university research associates. Stems per acre decrease over time through the use of herbicides, as does associated maintenance costs.

New Hampshire

The state of New Hampshire under the code of Administrative Rules (505.06), has established a number of regulations related to pesticide use (herbicides are considered a pesticide) and relating to utility use for the control of brush or cut stumps. The New Hampshire code is particularly specific regarding pre-treatment notification. Utility notification required between June and October 15, directly to residents within 200 feet 10 days prior to treatment. Notification in newspapers once for a 2 week period at least 45 days prior to treatment and includes cut-out coupon for all abutting owners to receive notice 30 days prior to treatment.

Under New Hampshire general utility regulations there is a section that provides landowners with an alternative to the use of herbicides. Under this section, a utility must offer an alternative to the use of herbicides to objecting landowners. However, the land owner is obligated to pay the utility the additional cost of the alternative vegetation management method above what the herbicide application would have cost. The cost of cutting has been established/approved by the public utilities commission and reflects the increased cost the utility will incur in providing an alternative to herbicide use.[2]

[2] Title XXXIV, Public Utilities, Chapter 374, general Regulations: General Public Utility Duty; section 374:2-a

4.2.5 Hazard Trees

Unitil-NH interruption data does not distinguish between trees that cause outages through growth across conductors, or as a result of mechanical failure of tree limbs or trunks. Comments entered by the troublemen, anecdotal evidence and workload data regarding the percent of trees in contact with conductors suggest that 40 percent or less of the customer minutes of tree-caused outages on the Unitil-NH system result from tree growth[3]. Following detailed root cause analysis of outages reported as tree-related, most utilities that have implemented a systematic preventative maintenance program find that 80 percent or more of tree-caused outages are a result of trees that fail structurally. A portion of these trees are often either dead or structurally unsound. These trees, termed hazard trees, represent a particular risk to system integrity because of their location and/or condition. However, previous studies involving multiple utilities have reported about 60 percent of these failures to be from limbs of trees that are healthy and without noticeable defects. This, of course, leaves the other 40 percent that did contain failure predisposition factors that could be addressed through an intensive hazard tree mitigation program. These same studies also indicated that over 40 percent of all trees that failed and caused interruptions were within five feet of conductors – primarily to the side of conductors, while another 40 percent were over 20 feet away. An in-depth analysis of Unitil-NH's 2009 tree-caused outage date shows there were at least 9 hazard tree outages that account for 532 customer-hours of interruption. Consequently, it is important to identify which trees are predisposed to failure on the Unitil-NH system, target those high risk trees, and reduce the total number of trees that are close to conductors. This will include trees within 10 feet from conductors but can include any trees that are close enough that if they fell could strike the line.

Conditions typically associated with hazard trees include co-dominant stems, bark inclusion, and decay. Hazardous trees in the overall tree population change over time and in relation to disease or insect infestations that may become common in the area. Some states (Michigan, Ohio, Indiana and Illinois) have begun to experience the impact of the Emerald Ash Borer, an introduced pest that has the potential to cause the death of all ash trees. Should this pest be introduced to New Hampshire, dead ash trees could become a new source of interruptions caused by tree failures and an expense related to tree removal. Fortunately, ash represents a very small percentage of the Unitil-NH tree population (0.4 %). Dutch elm disease continues to be a cause of many dead trees within the Unitil-NH service territory. Elm species make up approximately 1% of the tree population. These and other dead trees can be a risk to overhead lines as they deteriorate and drop limbs.

Cyclic vegetation maintenance on utility systems primarily addresses tree growth issues. Developing a storm hardened electrical system, one that is more resilient under the impacts of wind, ice and snow, should also be taken into account when developing a vegetation management plan. Those "best in class" vegetation management programs include considerations for targeted tree removal and have developed extensive hazard tree identification, rating and mitigation programs. Unitil-NH should give consideration to both tree removal and hazard trees as they compose approximately 20 percent of the total tree population. As stated in Section 4.2.1, in 2009 approximately 22 percent of tree-caused outages and 43 percent of the customer minutes (CMI) of tree caused interruptions were from

[3] In 2009, approximately 60% of customer minutes of tree cause interruptions were from broken limb, broken trunk or up-rooted trees. Unitil-NH does not define the types of outages; ECI interpreted this information from the Unitil troublemen comments for each outage.

hazard trees. Development of a prioritization plan to address this issues and an adequately funded plan over several years will address the risk but keep the associated annual cost at a more manageable level. Developing a storm-hardened tree population is one of the key elements Unitil-NH can implement to improve system reliability. Eliminating those trees prone to failure will reduce system damage (broken poles/downed wire) and greatly improve system average customer outage durations (CAIDI).

4.2.6 Outage Reporting

Many utilities routinely require detailed tree interruption information following tree-related interruptions. Unitil-NH does not currently conduct post-outage investigations. Vegetation interruption investigations collect such attributes as tree species, tree or limb distance from the conductor, tree height and diameter, length of limb that failed (if applicable), voltage and number of conductors as well as observations on the condition of the tree (internal decay, up-rooted, broken limb vs. broken trunk, growth caused interruption vs. broken limb or up-rooted tree). These are critical factors in determining the effectiveness of a vegetation maintenance program and they provide key information to the vegetation manager that can be used for strategic planning.

An understanding of the vegetation-caused interruption data coupled with an understanding of Unitil-NH's current clearance specifications and management practices can lead to targeted enhancements to Unitil-NH's vegetation program and reduce specific types of vegetation caused interruptions. As an example, through an outage investigation program Unitil-NH may find that certain species are responsible for a higher percentage of interruptions than others. Therefore, targeting specific maintenance efforts towards these species should have a significant impact on reducing vegetation-related outages, especially when coupled with data developed in this report regarding tree species on the distribution and sub-transmission systems. ECI recommends that Unitil-NH implement a formal tree-outage investigation program.

ECI recommends that Unitil-NH consider modifying the existing interruption reporting system by adding additional descriptions related to tree-related interruptions. This will provide a better understanding of how trees are causing outages. The following are suggestions for three tree-caused outage categories, which should be separated by voltage:

- Tree Growth: All outages occurring as a result of tree limbs that have grown into or across conductors, resulting in an outage.
- Tree Breakage: All outages occurring as a result of on-ROW (within normal clearance zone) tree limbs or trunks breaking, falling on distribution equipment and causing an outage.
- Off-ROW Tree: All outages occurring as a result of tree limbs or trunks from off-ROW (outside the normal clearance zone) trees breaking or falling on distribution equipment and causing an outage.
- Storm or severe weather: All outages occur during a severe weather event would fit into this category. Many utilities are adopting the IEEE for calculating storm exclusions.

Further, ECI suggests the following related to outage reporting:

- Initiate a process of outage investigation by qualified utility arborist. This will serve a two-fold purpose. First, it will help ensure the accuracy of cause reporting, making the data more useful and reliable. Second, it will facilitate the collection of information regarding what tree conditions lead to service interruptions. This will enable the development of processes targeting trees with the highest risk of failure. Appendix 5.8 provides an example of data that is collected by another utility. Only a limited sample of outages caused by trees need be investigated to provide these benefits.
- Continue to capture and report tree-related outage data by important risk factors such as voltage and number of phases present. Ensure consistency in recording the data.

4.2.7 Conclusions about Work Practices

Recommendations relative to the work practices can be summarized as follows:

- Unitil-NH should improve tree maintenance specifications by referencing ANSI standards, modifying the clearance table, and addressing property owner permission for use of herbicides.
- Implement enhanced clearance for fast growing species on the Unitil-NH system, such as Red Maple. Continue to remove trees in the cost effective 4 to 12 inch diameter class to the full width of the right-of-way.
- Implement a limited program for the removal of overhanging tree limbs based on the currently known problematic areas and for weak-wood species and white pine in all other areas.
- Begin to treat stumps of all deciduous trees and brush as a routine part of the tree removal and brush cutting operation on the distribution system.
- Begin to manage sub-transmission ROW using IVM. Including herbicides as a tool in the management of the ROW. This will reduce the stem count/brush density per acre over time, thus, reducing maintenance cost.
- Begin to evaluate tree-related interruptions to increase Unitil-NH's understanding of the specific conditions that are most common among trees that fail and cause outages.
- Increase the amount of "Reliability Enhancement" as this targeted program provides a fast/cost effective method to improve system reliability related to vegetation. This should be a part of a system-wide Reliability Centered Maintenance (RCM) program (see Appendix 5.4).
- Reduce the maintenance cycle on 4kV single-phase circuits to 7-years and the 13.8kV multi-phase circuits to a 4-year cycle.
- Introduce a systematic program to address hazard trees on the system.

4.3 Program Management and Supervision

4.3.1 Management

Sound program management forms the basis for an effective line clearance program. ECI's experience with other electric utilities throughout North America, together with best practices benchmarking studies, have pointed toward centralized management of a vegetation management program as the most effective approach. One knowledgeable individual who establishes standards for cost-effective work practices and then enforces them in a uniform manner is credited to the success of these programs. Unitil–NH has established a centralized strategic vegetation management organization, with the tactical management conducted at the Region level. Unitil-NH does not currently employ an arborist on their staff, but should consider the use of a professional Arborist to manage the overall vegetation management program.

4.3.2 Supervision

Program effectiveness relies on qualified supervisory personnel capable of work specification interpretation, contractor performance evaluation, contract administration and credible communication with customers and municipal officials. While there is not an arborist on the Unitil-NH staff, there are competent personnel in place in the form of 2 regional Field Supervisors who spend approximately thirty-percent of their time on vegetation management. In addition, the line clearance contractor has one part-time general foreman.

To compare Unitil-NH's level of oversight with what other utilities provide, the role of the contractor's general foremen must be considered. ECI has found that well-run utilities may distribute responsibilities between their internal staff and the contractor in a variety of ways and attain success. The combined resources allocated to management and supervision, however, is the common factor among effective programs (see Figure 4-2).

Figure 4-2. Levels of Supervision Allocated for Operational Oversight[4]

When making operational recommendations relative to the supervision of the vegetation program, ECI presents four important observations. First, taps and other areas skipped due to

[4] Unitil-NH Has the .6 FTE's supervising vegetation maintenance and .1 FTE Contractor General Foremen. Unitil staff 2-thirds of their time on non-vegetation management issues. The Contractor General Foreman primary responsibility is pre-checking customer tickets prior to dispatching a tree crew. NES-NH averages 6 T&M crews.

customer refusals must be recorded and a system developed to follow-up on all "skipped" work areas. Second, tree-related outages, customer and governmental requests, and all operations requests for tree maintenance need to be investigated and prioritized prior to assignment to crews for completion. This is important to reduce the trend toward increasing expenditures on reactive maintenance work. Third, the contractor's general foremen should be allowed to focus on crew training, safety and organization, production and achievement of specified clearances, without significant distraction from customer issues. Finally, management of lump sum contracts requires significant inspection time by Unitil-NH staff to assure contractor compliance with standards.

While Figure 4-2 seems to suggest that Unitil has adequate contractor supervision/oversight, all three ECI observations argue for increasing the current level of supervision. Therefore, it is recommended that Unitil-NH provide for an increase in the level of supervision, or at a minimum full-time Unitil staff supervision.

System Arborist

Unitil-NH has expressed a concern that their existing management structure lacks an individual who has the authority and expertise to ensure that cost-effective work practices and operating procedures are implemented consistently on a system-wide basis. The program will benefit from technical expertise at the regional level and could realize significant benefits from utilizing professional personnel to handle property owner contact duties.

Based on these areas of concern, ECI recommends that Unitil makes changes in the management structure of its line clearance program. The recommended changes are designed primarily to standardize line clearance operations system-wide and to ensure that program policies and specifications are implemented on a consistent basis. In order to accomplish this objective, Unitil-NH should do the following:

- Establish the position of System Arborist and provide this individual with the authority to implement the recommended program.
- System Arborist should report directly to the Director- Electric Operations.

The System Arborist should provide the technical expertise and overall direction for the line clearance / vegetation maintenance program. The main responsibility of this individual is to continually improve system reliability by ensuring quality tree-to-conductor clearance for minimum long-term cost. The System Arborist should be ultimately responsible for quality control, supervision, and review of all line clearance work as well as adherence to vegetation management budgets.

The System Arborist should participate in trade associations and organizations involved in vegetation control activities. This will facilitate the exchange of information with other utility vegetation management professionals and enable the System Arborist to keep abreast of research and development in the industry. The goal is to continually incorporate state-of-the-art technology and best management practices into the Unitil program, thus improving long-term cost effectiveness.

The System Arborist must have strong communications, analytical, and technical vegetation management skills. A minimum of a Bachelor's Degree in Forestry, Horticulture, or similar field of study is recommended. The System Arborist must be a strong representative for the line clearance program to upper level management and must be able to statistically evaluate crew productivity data and develop justifiable budget requests. This individual must also represent the program to municipal officials, regulating agencies, line clearance personnel and the general public.

Regional Arborists

The Regional Arborists will be responsible for field implementation of Unitil's line clearance program and the evaluation of line clearance crews and contractors within their area of responsibility. These individuals will manage the contract line clearance operation in their respective regions and interface with customers and municipalities. It is recommended that there be one Regional Arborist for each Unitil-NH region.

The Regional Arborists should report, at least functionally, directly to the System Arborist. This will provide a measure of control over individual interpretation of company guidelines and ensure consistent implementation of appropriate work practices and operating procedures system-wide.

These individuals must ensure regional contractor compliance to ANSI A-300 standards and that crews are properly instructed on the correct and safe use of herbicides, customer relations involving herbicide applications and maintaining applicable herbicide application records. The Regional Arborists must keep abreast of pertinent federal, state, and local laws and regulations affecting line clearance.

Regional Arborists should coordinate all programs that provide ongoing information on field conditions, including tree crew production records (trees pruned, removals, herbicide use, and brush treatment), electric service interruption data and conduct post-outage investigations. These individuals should be responsible for evaluating this information as a basis for program planning, budget forecasting and ongoing work coordination within each region. The Regional Arborists must also provide technical instruction, expertise, and assistance to all regional personnel involved with the line clearance program and act as a liaison between the Regional operating Managers and the System Arborist.

The Regional Arborists will also be responsible for promoting the image of Unitil-NH as a good public service utility. Involvement in local community organizations will exemplify Unitil's public interest and civic commitment. These individuals should act as liaisons with local and municipal officials and university, college and extension personnel. Consequently, the Regional Arborists must have public relations skills in order to gain acceptance within and outside the company.

The Regional Arborist position should have a minimum of 3 years of experience in utility vegetation management and, preferably, a Bachelor's Degree in Forestry or a related field. International Society of Arboriculture (ISA) certification is also recommended for these individuals.

Participation in trade associations and organizations involved in vegetation control activities should be encouraged. This will enable the Regional Arborists to keep abreast of research and development in the industry, while exchanging information with other utility professionals. The goal should be to remain informed on current topics in the industry and incorporate appropriate technological advances into the program.

Both the System and Regional Arborist will coordinate the planning and execution of all Unitil vegetation management activities. This includes, pre-planning for lump sum work packets, post-outage investigations, customer refusal follow-up (referred from the contractor), quality control on contractor work to ensure adherence to clearance specifications, work quality, monitor contractor productivity and prepare monthly summaries for senior Unitil management. The summaries should include: production against goals, contractor productivity, budget status, tracking of customer complaints, tracking and work-down of customer refusals and other duties as assigned by Unitil senior management.

4.3.3 Work Planning and Customer Notification

Unitil-NH currently notifies customers (secures permission) prior to line clearance work through a letter mailed to all customers on a circuit. Customers who call in response to the mailing receive additional information about pending work. If no call is received it is taken as permission to prune. The contract crews may also contact customers as work progresses, especially if the work is more severe than anything previously completed. Written permission is required for the removal of trees and/or brush on the easement. Selection of work to be done is at the discretion of the tree crew, based on general instructions provided by Unitil Specifications. The contractor General Foreman is responsible for resolving complaints/refusal regarding the work. Issues the General Foreman is not able to resolve are referred to the regional Field Supervisor. Due to other duties, customer refusals are currently often left unresolved.

Clearance inconsistency, especially along single-phase lines, together with high interruption rates, suggest that a change in practice is required to reduce the number of trees and limbs in close proximity to lines that are capable of initiating outages. Any change in practice resulting in greater clearances normally requires additional communication with property owners to avoid adversarial customer relations. Additionally, opportunities to reduce future workload through the use of herbicides applied to cut stumps will require permission of the property owner. Many utilities achieve this permission for herbicide use as part of a process whereby the property owner signs a small form authorizing removal of specified trees, along with treatment of the stump with a registered herbicide to prevent re-sprouting.

Unitil-NH's contractor sometimes utilizes a work planner for enhanced maintenance and to resolve customer refusals. Additional planners may prove beneficial for audits and modified enhanced maintenance.

4.3.4 Conclusions about Management and Organization

Recommendations relative to the program management and supervision can be summarized as follows:

- Unitil-NH should add the services of a qualified System Arborist as well as a one Regional Arborist in each the Capital and Seacoast regions.
- Unitil-NH should require at least one full-time contractor general foreman for every 10 hourly crews and miscellaneous lump sum contract crews.
- Unitil-NH should increase the level of communication with customers prior to undertaking enhanced vegetation maintenance work or when clearance standards are significantly increased. This increased level of communication and face-to-face customer interaction should improve customer acceptance of greater clearance, especially on single-phase lines and areas where reliability enhancement clearing is implemented.

4.4 Contracting for Line Clearance

Three different approaches are commonly used by electric utilities to contract line clearance work. These include "time and material/equipment" (T&M), "unit price" and "firm price" or "lump sum" pricing strategies, and are more fully described in the Appendix. Each has advantages and disadvantages that are important to understand, and there are multiple variations possible within each pricing family. Each carries a different risk profile for the contractor and the utility. Unit price and firm price contacts are inherently performance-based contracts. However, T&M with incentive pricing can also be a performance-based contracting strategy. ECI recommends that Unitil-NH utilize performance-based strategies as their primary contract methodology along with a combination of unit price and lump-sum work. This includes continuation of firm price or cost per mile contracts for specific circuits and a unit cost ($/acre) for the sub-transmission mowing / herbicide treatment. Well-documented inspection of completed work and establishment of clear standards are critical to achieving value from firm price contracts. Where clearance requirements may be variable due to customer concerns or the scope of the work is not clearly defined (as with ticket work), T&M normally can provide better value. Some utilities clearly define the project scope prior to firm price bidding through development of detailed work plans. Pre-planning to define clearances, clearance exceptions, and removals has proven to be a very effective strategy in receiving cost competitive bids. Contractors provide pricing on the defined work scope that the utility has per-designated, thus eliminating guess work on the part of the contractor and eliminating the “contingency” cost that contractors build into bids. However, this does require additional effort on the part of Unitil-NH to have personnel available and knowledgeable to perform the pre-work planning as well as post work acceptance.

4.5 Record Keeping

Unitil-NH metrics regarding the line clearance program does not provided adequate information necessary to most effectively and efficiently manage the program. Data is collected from contractor timesheets and transferred to a Unitil Vegetation Control Report for each crew and week-ending date. The data includes information regarding number of units (spans) maintained, labor and associated equipment hours. Work is categorized as scheduled, unscheduled, construction work order, and storm, clear or open spans and customer request. No unit data (# of trees) is captured to provide production metrics around these categories. The only data related to clearing describes the type of clearing: trimming (light/medium/heavy); ground cut; dead/hazardous/tree limbs removed. Additional details about contractor production would allow movement toward a performance-based component within a T&M contract, or become a basis for a unit cost removal component of firm priced contracts. At a minimum, more detailed production data would provide an accurate assessment of production cost for various work-types for both internal and external comparisons. Both record keeping software and record keeping services are available to provide streamlined invoice verification, cost tracking by asset and work type, metrics for process improvement and documentation of work accomplishment. Currently data from the Unitil data sheet is entered into Excel spreadsheets manually. Data collection requires three manual steps, tree crew to time sheet; Unitil office staff transcribes contractor data to in-house data sheet and finally input into a spreadsheet.

4.6 Maintenance Strategies and Cost Projections

4.6.1 Reactive Maintenance

Overall reactive maintenance has increased in recent years. Some of this work is necessary to assist customers with safe removal of trees within 10 feet of conductors, and some is directly related to tree maintenance necessary to avoid imminent outages. However, crews are also assigned to prune trees to eliminate incidental contact with primary conductors. This "hot spot" pruning does not normally provide improvements in reliability. Unitil-NH should seek to reduce expenditures related to responding to non-critical customer requests and reaction to individual trees making incidental contact with conductors.

4.6.2 Preventive Maintenance Strategy Alternatives

Unitil-NH has implemented a somewhat traditional cycle or time-based scheduling system, where cycle length is determined by voltage and construction type (single-phase vs. multi-phase). Vegetation-caused interruptions are high by industry norms, based on both exposure miles and tree density exposure (see discussion in Section 3). Funding and work accomplishment has varied somewhat from year-to-year.

One of the primary purposes of this study is to determine the optimal schedule and associated budgets necessary to maintain a desired level of service reliability. It is clear from analysis of interruption data that frequency of maintenance is not a reliability performance driver, but rather, *the scope of maintenance performed drives future reliability results*.

Maintenance strategies are often thought of in terms of cycle lengths or planned years between maintenance. However, not all circuits or system components have the same risk or the same impact on overall system performance. The potential for a tree branch to become a pathway for a sustained interruption is higher for multi-phase lines than for single-phase lines, and higher for a 34kV line than for a 4kV line. Construction types, as well as voltage, carry varying degrees of tree-related risk to system integrity, and the cycle lengths of different system components have varying impacts on Unitil-NH's customers. Although more intensive management is required, split cycles (based on construction type, voltage, tree density and clearance opportunities) and targeted mid-cycle inspection (with selective maintenance of multi-phase lines) can help maintain acceptable levels of reliability at lower overall costs. ECI recommends that Unitil-NH:

- Continue the split cycle based on voltage and construction-class.
- Incorporate a shorter cycle for single-phase (7-year) and multi-phase 13.8 kV/34.5 kV (4-year).
- Acquire additional clearance for targeted fast growing species, Red Maple in particular.
- Cut and treat brush growing under the system multi-phase 13.8 kV/34.5 kV construction.
- Begin removal of hazard trees on the multi-phase 13.8 kV/34.5 kV system (a 7-year removal plan), and in year 8, start a 7-year work-down of hazard trees on the single-phase as well as multi-phase voltages.
- Add a mid-cycle inspection/pruning component for multi-phase 13.8 kV/34.5 kV to address the fastest growing tree species (this represents approximately 8 percent of the total tree population).

- Add a targeted mid-cycle program to the single-phase 4kV system and below. Program will target poles with critical system components (transformers, cut-outs, etc.) that are prone to vegetation growth-caused outages.
- Continue a 4-year cycle for the sub-transmission voltages, incorporating IVM practices *and* incorporate hazard tree inspection and removal as a part of the maintenance strategy.
- In year 8 (beginning of the second cycle) begin a tree removal program of the fast-growing trees directly under the conductors that require top-pruning. Funding will be shifted from hazard tree program (caught up on back log during the first 7-years) to the tree removal effort.

Table 4-1 summarizes ECI's recommended program (Option I) for adoption on the Unitil-NH system. Key changes from current maintenance program are: the reduction of cycle lengths for single and multi-phase lines, addition of a 7-year hazard tree removal program, addition of a mid-cycle program for multi-phase and a modified mid-cycle program for single-phase construction. The current sub-transmission program remains unchanged. Option II is the same as Option I except that it has an accelerated 3-year hazard tree removal program.

Cost projections for these recommendations are provided in detail in Section 4.6.3 of this report, as well as projected impacts on tree-to-conductor contact and tree-related reliability. There are numerous program cycle options and combinations that were considered, however, ECI believes that Option I provides the greatest opportunity in a reasonable amount of time to positively impact the system reliability in a cost effective manner.

Table 4-1. ECI Program Strategies

Options	*Cycle Description*
ECI Recommended Program Strategy ***Option I*** *Gradual Impact on system Reliability at a lower annual cost. (7-Year Hazard Tree Removal Program)*	• 7-year singe-phase & 4-year multi-phase Scheduled Vegetation Maintenance program (NOTE: an increase in side-clearance distance on multi-phase from 8-feet to 10-feet will provide adequate clearance for a 5-year cycle based on system re-growth rates). • Mid-cycle prune all multi-phase and selected single-phase pole locations with critical equipment (transformers, cut-outs, etc.). • Brush removal on multi-phase and single-phase; • Hazard tree removal on multi-phase (1/7th of system per year for 7 years; at year 8 expand to include single-phase). • 4-year cycle for the sub-transmission. Optional: Removal of tall-growing tree species on ROW under conductors (currently being top-pruned): 4-year cycle on multi-phase and at year 4 start an 8-year removal program on single-phase.
Option II: *Quickest Impact on System Reliability at a higher annual cost.* *(3-Year Hazard Removal Program)*	• 7-year single-phase & 4-year multi-phase Scheduled Vegetation Maintenance program (NOTE: an increase in side-clearance distance on single-phase from 8-feet to 10-feet will provide adequate clearance for a 5-year cycle based on system re-growth rates). • Mid-cycle prune all multi-phase and selected single-phase pole locations with critical equipment (transformers, cut-outs, etc.). • Brush removal on multi-phase and single-phase; • Hazard tree removal on multi-phase (1/3rd of system per year for 3 years; at year 4 expand to include single-phase). • 4-year cycle for the sub-transmission. Optional: Removal of tall-growing tree species on ROW under conductors (currently being top-pruned): 4-year cycle on multi-phase and at year 4 start an 8-year removal program on single phase.

4.6.3 Estimated Costs

Cost and Benefits of Cycle Option

When a 4-year cycle is compared to a 5-year cycle, it is recognized that there are some increases in biomass and maintenance time associated with the increase in cycle length. However, those increases are not as significant as the cost of maintaining 25 percent more miles each year. Shorter cycles should provide some enhanced benefits to warrant the additional cost. These benefits, some of which can be documented, include:

- Reduced interruptions associated with tree growth
- Reduced customer interruptions (CI) associated with tree failure/breakage
- Reduced restoration costs proportional to the reduction in interruptions
- Reduced customer inquiries and complaints regarding trees in close proximity to conductors
- Reduced outage restoration cost commensurate with the reduction in number of outage events.

On the basis of the vegetation workload survey, growth study and historic production costs, proposed program cycle and funding, many program alternatives were reviewed by ECI. Tables 4-2 and 4-3 provide projected vegetation maintenance program costs for two alternative strategies.

It should be noted that the term "cycle" is a planning term reflecting the average frequency circuits must be trimmed. Specific conditions will necessitate circuit-specific variance around this average cycle length. Reliability metrics and field observations should be used to modify the preventive maintenance strategy in order to complete highest risk circuits first during a scheduling year, or push individual circuits forward or backward by one year. Unitil–NH has separate cycles based on number of phases (multi or single) and voltage.

Outage restoration is a significant cost for Unitil-NH and reductions in tree-caused interruptions will result in a reduction in these restoration costs.

Table 4-2 provides an overview of annual cost for Option I (ECI’s recommended option). This option provides a 3-year hazard tree removal schedule on multi-phase lines. It also provides projected annual cost for budget years 1-7, 8-14 and 15-18. The hazard tree prioritization plan must be developed where-by the highest risk trees (dead or extensive decay) at the highest-risk locations (highest voltage-multi-phase lines) are removed first. In addition, brush removal and “trapped tree” removals are funded to begin reducing stem count per mile and reduce future workloads.

Table 4-3 provides an alternative option (Option II) where hazard tree removal on multi-phase is accomplished over 3 years. It also provides projected annual cost for budget years 1-3, 4-6 and 7-10.

Several metrics were calculated for this cycle strategy recommendation related to impact on long-term tree contact with conductors, projected tree growth interruptions, and interruptions avoided through enhanced tree maintenance. Table 4-4 summarizes the cost for ECI’s recommended Option I and an Option II.

ECI believes that Option I will provide the greatest improvement in reliability while maintaining relatively low long-term annual cost; however, it is significantly higher than current vegetation management expenditures. Option II achieves reliability improvement in a much shorter time-frame, but, at a higher cost per year.

Table 4-2. Recommended Program Strategy Annual Cost (Option I):7-Year Hazard Tree Cycle and Moving Forward for Distribution with Sub-Transmission Cost[5]

VM Activity	(Budget Yr. 1-7)	(Budget Yr. 8-4)	(Budget Yr. 15-18)
Scheduled maintenance (Tree pruning/removal)	$1,246,000	$1,246,000	$1,246,000
Brush	$ 20,000	$ 20,000	$ 20,000
Mid-cycle	$ 138,000	$ 138,000	$ 138,000
Hazard Removal (7yr)	$ 800,000	$ 500,000	$ 300,000
Reliability Enhancement	$ 100,000	$ 100,000	$ 100,000
Un-scheduled	$ 40,000	$ 40,000	$ 40,000
TOTAL Distribution	**$2,344,000**	**$2,044,000**	**$1,844,000**
Sub-Transmission	$ 80,000	$ 80,000	$ 80,000
TOTAL VM PROGRAM	**$2,424,000**	**$2,124,000**	**$1,924,000**

Table 4-3. Option II: 3-Year Hazard Tree Cycle and Moving Forward for Distribution with Sub-Transmission Cost[6]

VM Activity	(Budget Yr. 1-3)	(Budget Yr. 4-6)	(Budget Yr. 7-10)
Scheduled maintenance (Tree pruning/removal)	$1,246,000	$1,246,000	$1,246,000
Brush	$ 20,000	$ 20,000	$ 20,000
Mid-cycle	$ 138,000	$ 138,000	$ 138,000
Hazard Removal (7yr)	$1,755,000	$ 500,000	$ 300,000
Reliability Enhancement[7]	$ 0	$ 0	$ 0
Un-scheduled	$ 40,000	$ 40,000	$ 40,000
TOTAL Distribution	**$3,199,000**	**$1,944,000**	**$1,744,000**
Sub-Transmission	$ 80,000	$ 80,000	$ 80,000
TOTAL VM PROGRAM	**$3,279,000**	**$2,024,000**	**$1,824,000**

[5] Costs expressed in 2010 dollars. Represents annual cost associated with a 7-year hazard tree removal program.
[6] Costs expressed in 2010 dollars. Represents annual cost associated with a 3-year hazard tree removal program.
[7] With accelerated hazard tree removal there should not be a need for reliability enhancement.

Table 4-4. Comparison of Expenditures ($ 1,000) Required for Implementation Of Two Alternative Management Strategies [1]

Management Strategies ➔	**ECI Recommended Program Option I** [1] 4-Year multi-phase 7-Year single-phase + Multi-phase Mid-cycle and targeted single-phase mid-cycle + hazard tree removal on three-phase (1/7th per year)	**Option II** 4-Year multi-phase 7-Year single-phase + Multi-phase Mid-cycle and targeted single-phase mid-cycle + hazard tree removal on three-phase (1/3rd per year)
1st cycle [2]		
Number of crews required:	8	12
Scheduled	$1,246	$1,246
Mid-cycle	$138	$148
Un-Scheduled	$40	$40
Brush	$20	$20
Hazard Tree removal	$800	$1,755
Reliability Enhancement	$100	0
TOTAL DISTRIBUTION	$2,344 [3]	$3,199 [3]
Sub-transmission	$80	$80
TOTAL VM PROGRAM [6]	$2,424	$3,279

ESTIMATED LONG-TERM RESULTS

Current CI [4]	End of Year 3-Excellerated Hazard Tree Removal [5]	End or Year 7- Extended Hazard Tree Removal [5]
6,571 single-phase 40,777 multi-phase	2,175 single-phase 8,556 multi-phase	

NOTES

[1] Costs expressed in 2010 dollars.

[2] Based on the workload projections (i.e., number of trees and acres of brush) and the average man-hour cost per tree pruned of $68.84. This is based on Unitil crew production rate of .68 MH/tree (weighted average of on-road and off-road production) and the MH cost of $36.27 per MH for contractor crew + Work Area Protection (police) $52 per MH. These costs were distributed uniformly over the specified cycle by appropriate work type and associated miles. The projections do not include incidental secondary/service maintenance or costs for management and supervision.

[3] Approximate Unitil-NH for 2009 distribution maintenance: $714,000 (adjusted for 2008 storm related clean-up cost of non-cyclic work).

[4] CI 2007-2009 average for tree caused was 47,331 at Unitil-NH (non-storm). Cycles: 7-year 1Ø & 4-year 3Ø.

[5] Reliability improvement implementing this recommendation is projected to be 10% CI for single-phase and 20% for multi-phase per the respective 4 and 7 year cycles.

[6] Implementation of the program recommendation will require the addition of a system arborist and at a minimum one regional arborist, two recommended (or the addition of 2 qualified VM work planners).

Unscheduled Work

Best practice vegetation management programs commonly have been able to limit unscheduled or reactive work to 10 percent or less of total production costs. Historically, Unitil-NH has done an excellent job of controlling the expenditures on unscheduled work well below the ten percent level. Unitil-NH should continue to control expenditures for unscheduled reactive maintenance. Over time, the need for some of this work should decrease as the average cycle length decreases.

Reliability Enhancement Program

Unitil-NH has periodically applied enhanced line clearance (Reliability Enhancement Program or REP) targeting a specific problem/location on the system. This has been effective in resolving reliability issues on circuits with extremely poor reliability performance. While this process can eliminate or fix isolated vegetation related reliability issues, it has not drastically improved overall system reliability.

ECI suggests that Unitil-NH continue with a limited REP program adhering to the following process steps:

1. Review worst performing circuits due to vegetation (i.e. top 5 to 10 percent).
2. Determine the type of vegetation outages causing the outages (growth, broken overhanging limbs, major trunk failures, up-rooted trees, broken major limbs or leads). Select the circuits after a thorough review of the trouble man's comments on the outage reports to determine the nature of the vegetation outage.
3. Conduct a circuit inspection (Multi-phase only) on the worst performing circuits to identify hazard trees (highly likely to fail due to disease, decay, structural defects, lean, etc.) overhang on week-wooded species and White Pine as well as the re-growth conditions (amount of clearance to conductors).
4. After investigation of the vegetation outage types and field survey/work plan, schedule to trim or remove the troublesome trees in specific targeted areas on the poorest performing circuits (Multi-phase only). This should include clearing around /near all equipment such as transformers, etc.
5. Pruning the entire circuit is not necessary on the REP program. If the majority of the circuit/single-phase taps have vegetation issues, move the entire circuit up on the cycle schedule and perform maintenance on the entire circuit.
6. If vegetation issues are found on the fused taps, the entire tap should be scheduled for pruning.
7. If the circuit is scheduled for the current year (or the subsequent year), consider moving it up in the schedule and prune as a part of the current year's program rather than an REP only.

Reliability and Tree-Line Contact Impacts

An analysis of Unitil-NH tree-caused interruption data determined that there is little correlation between tree-related interruptions and years since last maintenance. Unitil-NH has not been engaged in the current program long enough to draw any conclusions. Also, Unitil-NH tree-caused interruption data does not clearly define or segregate outages by cause type (growth, broken limb, broken trunk, up-rooted tree) therefore, a clear relationship between growth cause outages and cycle length cannot be made. However, based on ECI's workload survey and system growth-rate analysis, the percentage of trees by proximity to the conductors is available, Table 4-4. It should be noted that 38 percent of the total population on the Unitil-NH system are within 5 feet of the conductors.

Table 4-4. Tree Population Clearance to Conductor

Clearance	0-1ft	1-2ft	2-5ft	5-8ft	8-11ft	11-15ft	*TOTAL*
Percent	3%	11%	25%	36%	23%	3%	100%

As shown in the analysis of some industry tree-related data in Figure 4-5, tree growth-caused outages as a percent of total tree-related outages tends to increase with years since last maintenance. This information in combination with growth data and proximity data for Unitil-NH provides some of the basis for use in formulating cycle recommendations.

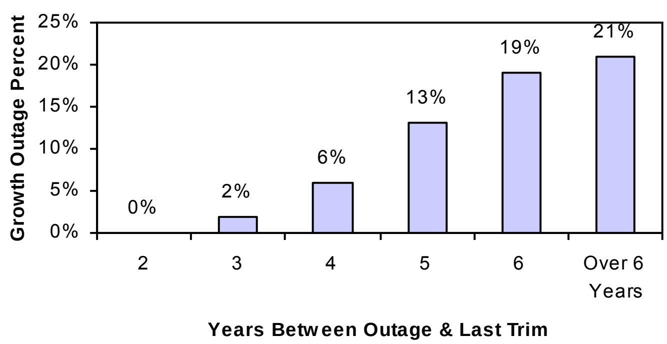


Figure 4-5. Industry Tree Growth-caused Outage Event Percentage of Total Tree-Caused Outage Events Investigated

Observations made by ECI on other utility systems support the premise that contact between trees and distribution conductors only rarely, and under certain circumstances, results in outage events. In order to achieve significant reductions in total tree-caused outages both growth and tree failure causes must be addressed. Unitil-NH's tree caused interruption rate per 1,000 trees in section 3 was 2.88. A reasonable goal for Unitil-NH is 1.2 interruptions per 1,000 trees. ECI's projections for reliability improvement are based on achieving this target.

Figure 4-6 illustrates the projected annual reductions in CI per year for ECI's recommendations for Unitil-NH single-phase maintenance. This option assumes prioritization of circuits based on recent CI per mile, resulting in annual reductions in outages over the course of the first cycle. Projected improvements are based on application of full compliance with clearance standards coupled with a mid-cycle inspection and tree maintenance near poles containing critical infrastructure equipment (transformers, cut-outs, etc.). Cumulative non-storm CI avoided through the implementation of this recommendation for single-phase maintenance is estimated to be nearly 4,400 (moving from 2009 CI of 6,561 to 2,175) by the end of the 7-year single-phase cycle.

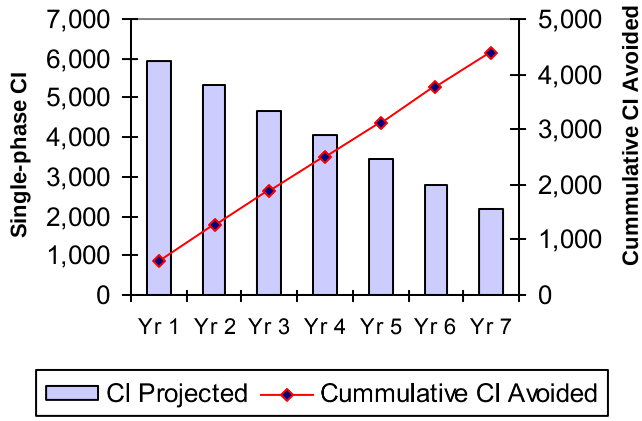


Figure 4-6. Unitil-NH Projected Non-storm Tree-caused Customer Interruptions (CI) Projected vs. Avoided per Year For Single-phase Maintenance

Figure 4-7 illustrates the projected annual reductions in CI per year on Unitil-NH Multi-phase lines based on ECI's maintenance recommendation (Option I) and Option II. ECI's recommendation is includes a 7-Year removal plan for all hazard trees. Option II offers an accelerated program where all hazard trees are removed in a 3-year period. As with the single-phase recommendation, this option assumes prioritization of circuits based on recent CI per mile. Projected improvements are based on:

- Application of full compliance with clearance standards; increased clearance on fast growing species (Red Maple) for 8-foot to 10-foot of clearance.
- Mid-cycle inspection and trimming of the "cycle-buster" trees that will re-grow into the conductors before the end of the current pruning cycle.
- Implementation of hazard tree removals totaling 1/7th of all hazard trees on multi-phase lines per year (for Option I). Implementation of hazard tree removal of 1/3rd of all hazard trees on the multi-phase lines per year (for Option II).

The cumulative non-storm CI avoided through the implementation of these two options for multi-phase maintenance is estimated to be over 32,000 (moving from 2009 CI on multi-phase of 40,770 to 8,566) at the end of the 4-year multi-phase trim cycle: I. With a 7-Year hazard tree program; II. With a 3-Year hazard tree program. Both achieve the same results the only difference being the time it takes to get there (three years vs. seven years).

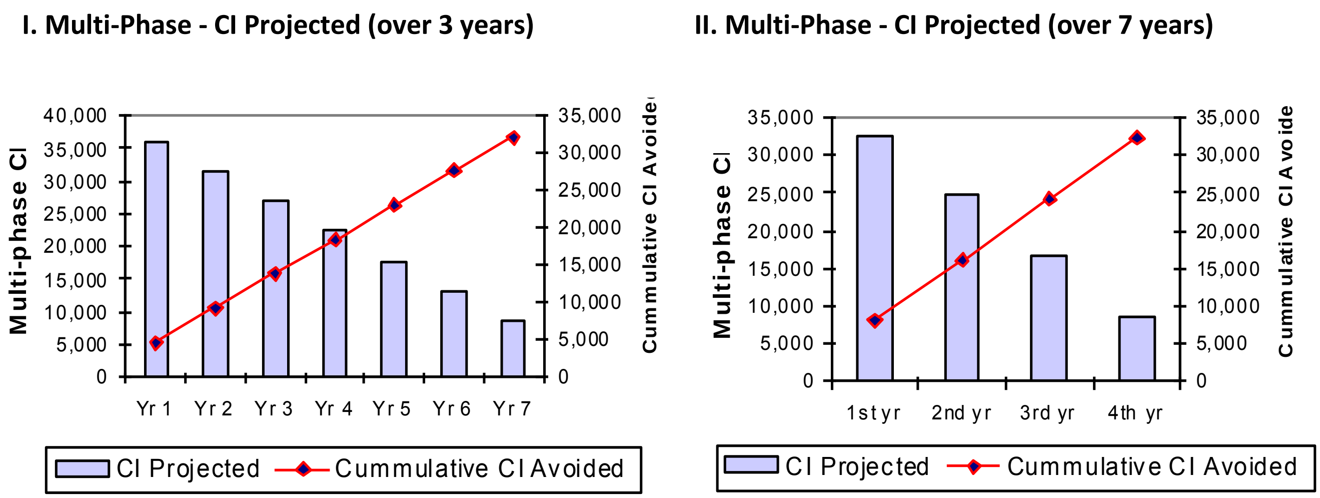


Figure 4-7. Unitil-NH Projected Non-storm Tree-caused Customer Interruptions (CI) Projected vs. Cumulative CI Avoided per Year for Multi-phase Maintenance. I. Shows Impact of a 7-year Hazard Tree Removal Program; II. Shows Impact of a 3-Year Hazard Tree Removal Program.

Table 4-5 presents projected cost per CI avoided for the ECI recommended cycle strategies. Unitil-NH should review this actual performance and allocate enhancement funding to circuits where the most benefit is likely. Figure 4-8 displays the cost per CI reduced for each strategy.

While additional vegetation management costs per customer affected can be substantial, reductions in outage restoration costs will offset a portion of these costs. The cost for CI avoided for singles-phase construction is much higher than for multi-phase construction. Some of that cost may be recovered through avoidance of the combined average storm and non-storm restoration cost.

Table 4-5. Unitil NH - Cost per CI Reduced Comparing ECI Recommendation-Option1 and an Option II, to Current Cycle Plan

Phases Present	Description	Annual Interruption Event Reduction Estimate	Event	Annualized CI Avoided Estimate	Miles	Current Cycle	Annual Cost No Cycle Change	Optimal Cycle	*Annual Cost ECI Plan	Budget Incremental Cost	$/CI Reduced
Single	7 year circuit cycle	28	22.47	629	717	13	$321,300	7	$702,253	$380,953	$605
Multi	4 year circuit cycle + 3 year hazard tree	36	222.79	8,020	334	6	$392,700	4	$2,428,624	$2,035,924	$254
Multi	**Recommended:** 4 year circuit cycle + 7 year hazard tree	21	222.79	4,679	334	6	$392,700	4	$1,638,590	$1,245,890	$266

*Cost comparison using Scheduled Maintenance Cost + Mid Cycle Cost + Hazard Tree Cost only.

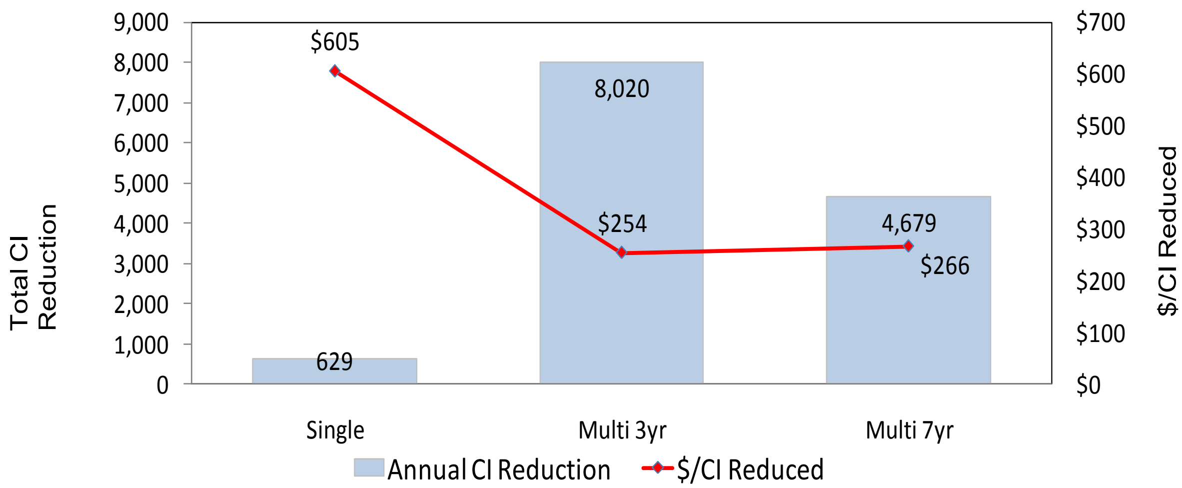


Figure 4-8. Unitil-NH Dollars per CI Reduced vs. Incremental Investment Comparing ECI Recommendation (Option I) to Current Program.

The Unitil-NH 3-year tree-caused average SAIFI is 0.63 for non-storm events and 0.96 for storm and non-storm combined. Figure 4-9 illustrates the projected and combined storm and non-storm tree-caused SAIFI for the recommended program strategy as compared to the current system SAIFI.

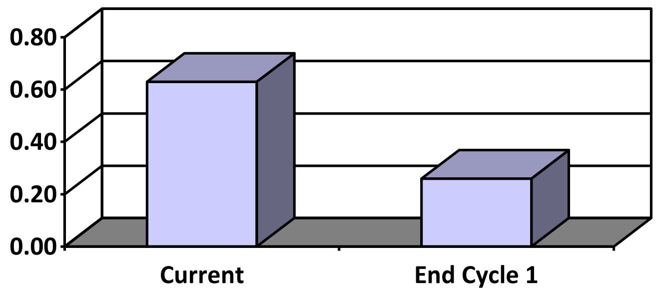


Figure 4-9. Projected Non-storm Tree-Caused SAIFI for Recommended Program Compared to the Current Strategy[8]

Other Opportunities

This study has focused on tree maintenance solutions for improvement of system reliability. While improved tree maintenance is part of the solution, it may not be the entire solution. Some utilities have found that changes to the overcurrent protection strategy, correction of inappropriate fuse coordination, use of additional fuses or reclosures, arrestor replacement or even reconductoring leads to reduction in interruptions previously associated with trees, or reductions in the customer impact of tree-related outages that do occur. The Appendix includes a white paper on prescriptive reliability, which addresses some of these issues.

4.6.4 Consistency of Funding

The recommendations provided will allow Unitil-NH to maintain sustained control of the vegetation growing near the distribution system. It is dependent upon consistent funding at the appropriate level, with adjustment for inflation and supervisory costs. Consistent funding is the single most important recommendation provided in this report. One of the biggest challenges Unitil-NH faces in funding the vegetation management program is the extraordinary additional cost that is mandated by local regulations. This additional cost adds significantly to the $/man-hour (represents between 35-50 percent of current $/m.h. without providing additional productivity benefits. Unitil-NH should look for regulatory relief or compensation via the rate structure to re-coup these mandated additional services by municipalities. ECI understands that there are overriding political considerations involved in resolving this issue.

[8] Improvement based on moving from 2.88 to 1.2 interruptions /1,000 trees (58-percent improvement). Figure 3-16 shows the nation-wide utility benchmark mean as .25 for SAIFI.

4.7 Revised Program Integration

Implementation of ECI's recommended optimum program will require planning and implementation in an orderly sequence of events. The anticipated steps to full implementation are:

1. **Approved funding**- the level of implementation will depend on the level of budgetary support for full implementation of the recommendation.
2. **Addition of System Arborist and Regional Arborists**- a great deal of planning must be done to implement the recommendation (circuit priority, bid vs. T&M, pre-planning cyclic maintenance and identification of hazard trees, inspection and tree identification for mid-cycle programs, program roll-out to municipalities and public, etc.).
3. **Finalize the proposed revisions to Unitil Vegetation Management Policy and Clearance Standards #OP5.00.**
4. **Develop detailed program plan**- prioritize work and develop the single-phase and multi-phase game plan for the first cycle.
5. **Determine type of contract** – T&M, T&M w/ incentives, Firm Price, Unit Price or combination of these contracting strategies.
6. **Secure line clearance contractor(s):** Put appropriate work out for competitive bid or assign crew under existing contract with current vendor.
7. **Roll out revised vegetation maintenance strategy to customers and municipalities.**
8. **If interim / immediate funding provided: Apply immediate funding to the Reliability Enhancement Program.**

Depending on how long it takes to implement steps 1 and 2, ECI anticipates that revised program strategy can be fully implemented within three to six months.

APPENDIX 5.1

UNITIL-NEW HAMPSHIRE SYSTEM ATTRIBUTES

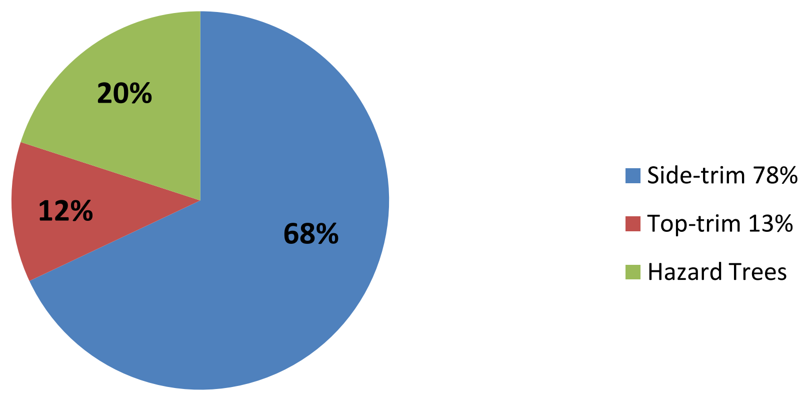


Figure 5.1-1. Vegetation characteristics as a Percent of Total Tree Population

NOTE-*WHEN ONLY CONSIDERING TRIMMING*:

- Of all trims: 85% are side-trim; 15% are top-trim represents
- Of all trims: 6 have major over-hanging limbs

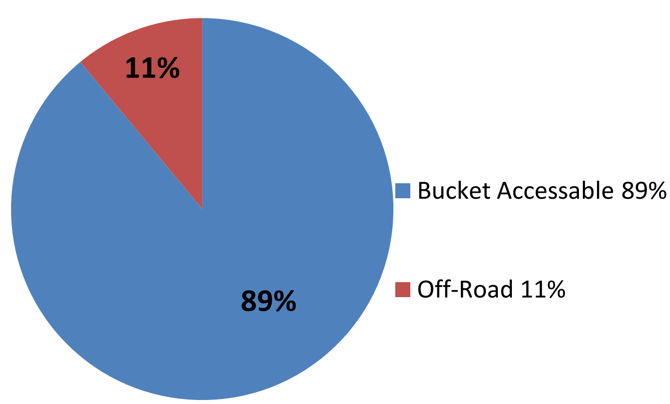


Figure 5.1-2. System Accessibility for Vegetation Maintenance

ECI Survey Results

Total trees: 161,437 **Total OH Miles**: 1,051 **Average Trees per Mile**: 153.6

On-Road: 90% **Off-Road**: 10%

Side-Trim: 85% **Top-Trim**: 15% **Open**: 12%

Trims: 128,648 trees Top-Trim: 19,666 trees Side-Trim: 108,982 trees

Removals: 1,269 trees total Single-phase: 853 trees Multi-phase: 410 trees
Removals represent approximately 1% of all trees on the system

Overhang: 9,052 trees Single-phase: 6,946 trees Multi-phase: 2,483
Severe overhang occurs on only 6-percent of the total tree population

Hazard Trees: 31,521 Single-phase: 23,154 Multi-phase: 9,176

Brush Acres: 93 acres total or an average of .089 acres per mile

Storm Damaged Trees: 862 trees or an average of .8 storm damaged trees per mile

Basis for Cost and Production Calculations

- Un-scheduled = 3%
- Mid-cycle: single-phase= 5% Multi- phase=10% (based on re-growth rate of Red Maple and its percent of total tree population
- Tree Contractor cost: Unitil-NH 2010 hourly contract rate
- Crew Production: .68 MH/trim (From ECI **TRES** evaluation of contractor production in April)
- Contractor cost per MN/Hr: Side-trim=$23.58; top-trim=$78.20 Weighted Average[1]: $53.24 / MNHR
- Work Area Protection Cost: $52/MH, Concord$104/MH Weighted Average= $53.24 / MNHR- applied to contract trimming labor at the rate of 50% per trimming MN HR
- Crew Cost: based on Unitil-NH production and cost + Work Area Protection cost =
    - Scheduled work: $53.24/ trim and $45.18
    - Mid-cycle:$66.84/tree
    - Brush: $1,800 / acre cut; $1,900/ acre cut and treat.

[1] Weighted Average: calculated taking % on=road/off-road and associated crew production for top-trim/side-trim cost per tree and including the average Work area Protection cost.

APPENDIX 5.2

GROWTH STUDY AND CONTACT UNITIL-NEW HAMPSHIRE

TABLE 5.2.1

Average Growth of Major Species on the Unitil Distribution System

Species	Pruning Type	Feet of Growth By Age of Sprout					
		1 Yr.	2 Yrs.	3 Yrs.	4 Yrs.	5 Yrs.	6 Yrs.
ASPEN	Side Mean	1.8	2.8	3.8	4.8	5.6	6.2
	Side Std Dev (±)	0.6	0.9	1.2	1.4	1.5	1.2
	Top Mean	2.1	3.6	4.6	5.8	6.9	7.9
	Top Std Dev (±)	0.7	0.9	1.2	1.1	1.2	1.6
WHITE PINE	Side Mean						
	Side Std Dev (±)						
	Top Mean	1.9	3.1	3.8	4.5	5	5.7
	Top Std Dev (±)	0.4	0.8	0.9	1.0	1.0	1.0
RED MAPLE	Side Mean	3.4	5.6	7.6	9.1	10.5	11.3
	Side Std Dev (±)	1.1	1.8	2.0	2.1	2.2	2.4
	Top Mean	4.0	6.5	8.5	10.0	11.5	
	Top Std Dev (±)	1.1	1.5	1.8	2.0	2.3	
SUGAR MAPLE	Side Mean	1.6	3.1	4.5	5.6	6.0	6.7
	Side Std Dev (±)	0.5	0.8	0.8	1.1	1.4	1.7
	Top Mean	2.4	4.4	6.5	8.9		
	Top Std Dev (±)	1.7	1.5	1.1	1.4		

		Feet of Growth By Age of Sprout					
Species	**Pruning Type**	**1 Yr.**	**2 Yrs.**	**3 Yrs.**	**4 Yrs.**	**5 Yrs.**	**6 Yrs.**
N. RED OAK	Side Mean	1.4	2.6	3.7	4.7	5.5	6.1
	Side Std Dev (±)	0.6	0.9	1.2	1.3	1.2	1.4
	Top Mean	1.7	3.7	5.3	4.4	6.1	6.3
	Top Std Dev (±)	0.5	1.7	2.5	3.4	2.3	1.0

TABLE 5.2.2

Predicted Percent of Side-Pruned Trees Capable of Conductor Contact. (Goal is 10% or less)

Minimum Pruning Clearance	PREDICTED CONTACT BY CYCLE LENGTH[1] 1 Year	2 Years	3 Years	4 Years	5 Years	6 Years
1 ft	100%	100%	100%	100%	100%	100%
2 ft	61%	75%	82%	86%	89%	90%
3 ft	26%	44%	56%	65%	71%	75%
4 ft	9%	24%	36%	46%	53%	59%
5 ft	2%	12%	22%	32%	39%	45%
6 ft	1%	6%	13%	21%	27%	33%
7 ft	< 1%	3%	7%	13%	18%	23%
8 ft	**0%**	**1%**	**4%**	**8%**	**12%**	**16%**
9 ft	0%	< 1%	2%	5%	8%	10%
10 ft	0%	< 1%	1%	3%	5%	7%
11 ft	0%	< 1%	1%	2%	3%	4%
12 ft	0%	0%	< 1%	1%	2%	3%
13 ft	0%	0%	< 1%	< 1%	1%	2%
14 ft	0%	0%	< 1%	< 1%	< 1%	1%
15 ft	0%	0%	<1%	< 1%	< 1%	< 1%

[1] Anything within 1 ft is considered in contact

TABLE 5.2.3

Predicted Percent of Top-Pruned Trees Capable of Conductor Contact (Goal 10% or Less)

Minimum Pruning Clearance	PREDICTED CONTACT BY CYCLE LENGTH[2] 1 Year	2 Years	3 Years	4 Years	5 Years	6 Years
1 ft	100%	100%	100%	100%	100%	100%
2 ft	84%	91%	94%	95%	96%	97%
3 ft	47%	67%	76%	81%	85%	87%
4 ft	24%	44%	57%	66%	72%	77%
5 ft	11%	27%	39%	50%	58%	65%
6 ft	5%	17%	26%	36%	45%	52%
7 ft	2%	11%	18%	26%	33%	40%
8 ft	1%	7%	11%	18%	24%	29%
9 ft	0%	4%	7%	13%	18%	22%
10 ft	**0%**	**2%**	**5%**	**8%**	**13%**	**17%**
11 ft	0%	< 1%	3%	6%	9%	13%
12 ft	0%	< 1%	1%	4%	6%	9%
13 ft	0%	0%	< 1%	2%	4%	6%
14 ft	0%	0%	0%	1%	3%	4%
15 ft	0%	0%	0%	1%	2%	3%

[2] Anything within 1 ft is considered in contact

TABLE 5.2.4

Predicted Percent of Trees Capable of Conductor Contact

(Goal 10% or less)

Minimum Pruning Clearance	PREDICTED CONTACT BY CYCLE LENGTH[3]					
	1 Year	2 Years	3 Years	4 Years	5 Years	6 Years
1 ft	100%	100%	100%	100%	100%	100%
2 ft	64%	77%	84%	87%	90%	91%
3 ft	28%	47%	59%	67%	73%	77%
4 ft	11%	26%	38%	48%	56%	61%
5 ft	3%	13%	24%	34%	41%	47%
6 ft	1%	7%	15%	23%	29%	35%
7 ft	< 1%	4%	9%	14%	20%	25%
8 ft	< 1%	2%	5%	9%	13%	17%
9 ft	0%	< 1%	3%	6%	9%	12%
10 ft	0%	< 1%	2%	4%	6%	8%
11 ft	0%	< 1%	< 1%	2%	4%	5%
12 ft	0%	< 1%	< 1%	1%	2%	3%
13 ft	0%	0%	< 1%	< 1%	1%	2%
14 ft	0%	0%	< 1%	< 1%	1%	1%
15 ft	0%	0%	< 1%	< 1%	< 1%	1%

[3] Anything within 1 ft is considered in contact

APPENDIX 5.3

PRESCRIPTIVE RELIABILITY
UNITIL-NEW HAMPSHIRE

Prescriptive Reliability

An Alternative to Traditional Vegetation Maintenance

Traditional Vegetation Management Programs

It has long been recognized that trees pose a significant threat to the reliable operation of overhead electric distribution lines. It is estimated that the industry spends in excess of 2 billion dollars annually maintaining vegetation growing in close association with conductors. Contemporary vegetation management programs emphasize the completion of preventive maintenance on a scheduled cycle in an effort to mitigate this threat. The focus of preventive maintenance work is to create and maintain clearance between conductors and trees. This is accomplished by establishing and applying uniform clearance specifications. Vegetation maintenance is typically conducted as a discrete program, with an emphasis on achieving efficiency in completing line clearance work.

Application Of RCM To Distribution System Maintenance and Vegetation Management

Recent work in applying Reliability Centered Maintenance (RCM) to a traditional distribution vegetation management program has led ECI to the belief that there is a significant opportunity for improvement in reliability and cost efficiency. Development of a RCM-based approach to overhead distribution maintenance has led to the realization that while it has been useful to manage traditional preventive maintenance efforts as discrete programs for the efficiency's sake, they need to be coordinated so that their composite effect is to optimize the performance of the system.

RCM focuses the allocation of available maintenance resources on the preservation of system function. The analysis process starts by identifying the important systems and the function to be preserved, which is reliable electric service. The process then moves to the identification of the important modes and causes of failure. With a clear understanding of the way interruptions occur, RCM uses a logical decision hierarchy to select preventive maintenance tasks that will be most effective in mitigating the identified risks to system function.

Understanding The Mode & Cause of Tree-Related System Failures

There are two basic ways trees cause distribution system interruptions. Trees fail structurally and mechanically damage the overhead utility infrastructure (mechanical mode), or trees provide a fault current pathway between conductors and /or ground, resulting in a short circuit fault (electrical mode).

The mechanical mode of failure is intuitively obvious and is a major cause of interruptions. Recent research in the area of electrical mode of failure has led to new insight as to what kinds of tree contact pose the greatest threat to reliability. Most tree contact with conductors begins as a high-impedance, low-current fault. Only under certain conditions will this fault evolve from high to low impedance and result in high levels of fault current, operation of overcurrent equipment and, subsequently, an interruption.

Some important points emerge from an understanding of the mode and cause of tree-initiated interruptions. First, the majority of incidental tree contact with energized conductors is of relatively low risk to reliability. Secondly, the structural failure of trees and branches is typically a major cause of both mechanical and electrical failures on a distribution system. Finally, that the overcurrent protection system plays a major role in determining if and how a tree-initiated fault is manifested as an interruption.

It should also be understood that more work needs to be done regarding incidental tree contact with conductors in order to fully understand issues such as the risk to safety by touch potential, risk of initiating wildfires, the economic significance of line loss, and the potential for conductor damage.

The New Maintenance Paradigm - Prescriptive Reliability
Applying a RCM focus of preserving system function to distribution vegetation management leads to a new way of thinking about preventive maintenance. Specifically the new approach places greater emphasis on assessing field conditions and determining the need for maintenance. Once the need is established, a specific reliability prescription is developed to effectively mitigate risk. The maintenance prescription is an integrated solution including both traditional elements and potentially non-traditional tasks as alternatives to tree pruning and removal.

This maintenance philosophy is consistent with an emerging industry business model that separates asset management and services responsibilities. By practicing prescriptive reliability, the asset represented as overhead distribution infrastructure is actively managed with a focus on preserving system function. This is achieved through an interactive process of resource allocation based on the effectiveness of results, which in this case is reliability. Individual maintenance services, such as the work done by tree crews, are managed for efficiency. This is typically accomplished through existing maintenance contractors. Rather than managing for efficient vegetation work (the service provider's focus) through a prescriptive reliability approach, the maintenance program is managed for optimal reliability by those assigned the responsibility for management of the asset. This avoids the potential for the maintenance program to become focused on the work of maintenance rather than the reason for maintenance.

Changes in the traditional approach to vegetation management. It's not about trimming more trees!
As has been discussed, the traditional cyclical approach to consistent scheduling and completion of preventive maintenance work is a management convenience. However, this philosophy often leads to less than optimal results. The reality is that various elements of the distribution system are not alike in terms of infrastructure, site, and the risk to reliability and consequence of failure. An emphasis on the performance of specific preventative maintenance based on condition assessment is a more intensive form of program management. However, this approach is justifiable given the opportunity for improvements in the effectiveness of resource allocation and reliability.

The second major change to the traditional vegetation management approach is driven by the knowledge that the greatest risk to reliability is caused by the structural failure of trees. This risk can be due to whole tree failure, branch failure within the tree's crown, and the deflection of branches. Loss of tree-conductor clearance is of lesser risk. The concept of clearance remains important, but it should not be as important as it has become. In fact, for much of a distribution system, clearance per se is one step removed from the true risk.

There are three areas where refinement needs to be made to the traditional program, which are as follows:

- *Clearance specification,*

- *Hazard trees maintenance*
- *Corrective maintenance.*

Preventive maintenance clearance specifications should place much greater emphasis on the elimination of potential causes of tree and branch failure. This also includes an important emphasis on proper arboricultural practices. This emphasis is driven by the goal to reduce the risk of structural failure. Trees respond favorably to proper pruning. Improper trimming causes stress, decay, and mortality, which effectively increases the risk of structural failure.

Secondly, because the risk of tree failure is predictable, regular hazard tree inspection and mitigation needs to be included as an important element of the vegetation management program.

Finally, armed with a new understanding of the mode and cause of tree-related interruptions, refinements can be made in the way corrective maintenance tree work (a.k.a. hot spotting) is managed.

Out-Of- The- Box Preventive Maintenance Alternatives
RCM begins with an initial assumption that reliability is an inherent design characteristic of the system. Within this frame of reference, structured decision logic is used to select optimal preventive maintenance tasks. This decision hierarchy defines the preferred approach to preventative maintenance as follows:

- Performing maintenance based on-condition
- Performing maintenance based on a fixed time interval
- Not performing preventive maintenance but repairing after failure
- Redesigning the system.

Redesign is recognized as the least preferred preventive maintenance alternative because it is often expensive. Nevertheless, it has a place in the maintenance program. The reality is that traditional vegetation maintenance tasks will not provide adequate risk mitigation for all sites and for all elements of the distribution system. In some small percentage of sites, adequate risk mitigation by traditional tree work is neither practical nor possible. In these cases, redesign alternatives deserve consideration.

Because RCM focuses attention on preserving system function, a number of strategies not traditionally considered to be maintenance items could be included in the maintenance prescription. Examples would include changes to the overcurrent protection system, corrective repair to existing infrastructure, and changes in the infrastructure. While the majority of resources will be allocated to preventive maintenance, (e.g. tree pruning and removal work), these other options will be considered and prescribed based on information acquired during field condition assessment.

Changes in Overcurrent Protection
Tree contact with overhead conductors initiates a fault. Under certain circumstances, the fault evolves from high to low impedance, with a corresponding increase in fault current levels. It is through the operation of the overcurrent protection system that the fault results in an interruption of some duration and size. There are a number of things that should be considered as means of mitigating the risk posed by trees.

Distribution systems are dynamic, and overcurrent protection coordination must keep pace. This is not always the case. A strong argument can be made to include a high level review of overcurrent protection coordination as part of the scheduled preventive vegetation maintenance of a circuit. The combined effect of tree maintenance together with overcurrent protection coordination would yield a return greater than either one done independently.

In addition to finding problems with overcurrent coordination, one will likely find missing, bypassed and/or disabled protection equipment. An example would be the occurrence of un-fused single-phase lateral taps. In this case, the argument can be made that a more effective means of mitigating risk than through tree pruning alone would be shifting part of the tree maintenance expenditures toward fuse installation. This is not to suggest that tree maintenance along single-phase lines isn't important. But with proper overcurrent protection, the intensity of that effort could be reduced, as compared to that required for multi-phase lines.

Finally, there is the issue of overcurrent protection philosophy. An understanding of tree-related fault mode and cause suggests that a review of some basic system protection practices may be in order. The practice of *feeder selective relaying*, (preserving fuses by recloser operation), is commonly practiced in the industry. One reason for this approach is the belief that most faults on the overhead system are transient in nature. As pointed out, if a tree-initiated short circuit is the cause of the recloser operation, it is because it has provided a low impedance fault pathway. If the tree/branch with fully developed fault pathway remains in contact with the conductor(s), the reclosing operation will close back into a low impedance fault pathway. Based on an understanding of mode and cause, there is reason to question an assumption that the majority of tree-initiated faults would in fact be transient.

ECI acknowledges that the overcurrent protection system must be effective in addressing faults of all causes. However, for circuits where trees pose the dominant threat to reliability, a *fuse-sacrifice* protection scheme should be considered.

Assessing Opportunities for Changes to Infrastructure

The most intuitively logical element of infrastructure to include in the overhead preventative maintenance program is inspection and correction of obvious defects. As has been discussed, an argument can be made for condition assessment and the development of a specific maintenance prescription. Assessment of the elements of the overhead infrastructure can be easily included in the inspection and maintenance prescription writing process.

On the basis of a generic economic assessment, it would be unlikely that the investment necessary to alter existing infrastructure is justifiable. However, conventional preventive maintenance tree work will not provide cost-effective risk mitigation on all sites and circuits. This is the same basic argument for redesign that supports consideration of change to overcurrent protection.

Here too, a RCM philosophy is useful in assessing where changes in infrastructure may be the preferred alternative. A system-based rather than site-based assessment of preventive maintenance costs is warranted. With an on-condition approach, the cost savings related to future maintenance may come from both a reduction in maintenance intensity and frequency.

The assessment involves comparing the present value of future maintenance costs on the old system to the cost of conversion plus the present value cost of maintaining a new system. Benefits such as potential improvements in reliability between systems should also be considered. The specific approach to economic analysis is beyond the scope of this paper. Conceptually speaking, however, when the cost to change a small portion of infrastructure provides a greater return in terms of cost savings and reliability than repetitive pruning and removal work, it should be included as part of the maintenance prescription. Finally, it is important not to imply high precision in the analysis if it cannot be supported by available data and assessment tools.

Changes To Conductor Orientation and Alignment.

Research into the electrical mode of failure points to the importance of considering the voltage gradient in assessing the risk presented by tree-conductor contact. A second factor is conductor orientation as it relates to branch capture, which is the likelihood of a branch intercepting and remaining in contact with two conductors and or a conductor and the neutral wire. Compact phase configurations create higher voltage gradients and increased potential for faults developing due to branch capture. Horizontal phase orientation can present a high risk of branch capture that could result in phase-to-phase faults. Opening up phase spacing and vertical construction presents lower risk. Both need to be considered when designing new lines, as well as a means to harden the existing system to tree-caused faults.

The other alternative strategy involving conductor position is their physical location. This alternative is intuitive. Realignment or rerouting of conductors to separate them from trees can reduce tree-related risk on some sites. Options include the use of offset arms (a.k.a. wing arm or alley arm), increasing pole height, and the physical relocation (and possible elimination) of the line. The important point is that while some of these options are quite expensive, they deserve consideration on a relatively small percentage of the system.

Changes To Overhead Conductors

The voltage stress gradient impressed upon a branch that falls between two or more conductors may also be reduced by the use of various coated conductor systems, which are collectively known as “tree wire”. The options include the use of coated overhead primary, where the coating provides some insulating characteristics, while not being technically rated as insulation. Spacer cable and true aerial cable systems provide increased resistance to tree-initiated faults since the coating serves increasingly as insulation. Getting creative, it is conceivable that adequate reduction in voltage gradient may be achieved with only one phase being replaced with a coated conductor. Finally, it is possible that a field-applied coating system can be developed, reducing the cost of this maintenance alternative by eliminating the need to re-conductor a section of infrastructure.

Tree wire can be applied with excellent results for those portions of circuits where the risk due to trees cannot be effectively mitigated by pruning and tree removal. The point once again is that by including these methods as options, the benefit of an integrated approach to prescriptive reliability can be achieved.

Conversion from Overhead To Underground

The final alternative to traditional tree pruning and removal is converting overhead infrastructure to underground. This is the most effective alternative in reducing the risk of tree-related service interruption. In fact, the risk due to trees is effectively eliminated. Undergrounding overhead lines can be prohibitively expensive. That said, it is important to state again the underlying philosophy;

traditional vegetation maintenance will not provide adequate risk mitigation on all sites and for all elements of the distribution system. In some small percentage of sites, where tree pruning and removal is neither practical nor possible, undergrounding deserves consideration.

The cost of underground conversion is highly variable. Factors such as the complexity and function of the overhead infrastructure affect cost of conversion. The construction methods required also influence cost as does the site location and the need for restoration following construction. Likewise, there are locations where cost can be relatively low and where the risk faced by overhead lines is very high. The point once again is that by assessing risk these sites will be identified. Underground conversion applied on a generic basis makes little sense. However, including undergrounding as a specific treatment for a specific high-risk situation can be very effective in improving the reliability of a distribution system.

A final note on underground conversion

Underground construction has greater potential to adversely affect the health of trees than do most overhead maintenance practices, because underground construction has the potential to destroy a tree's root system. Conversion work should include work practices intended to reduce the potential for adversely affecting trees. Useful information in this area can be found in the
National Arbor Day Foundation's booklet: "*Trenching & Tunneling Near Trees*".

Summary:

There is room for improvement with respect to traditional vegetation management programs. Too often, traditional vegetation maintenance focuses on just achieving clearance, and not on the ultimate goal, which should be reliability. Prescriptive reliability represents an opportunity to refocus maintenance resources on what counts; improved reliability. This philosophy relies on condition assessment and the development of a specific maintenance prescription. A much wider range of maintenance alternatives are available than are typically found in the traditional program. The resulting integrated maintenance solution provides for a more effective allocation of resources and improvement in reliability.

Reference: Utility Vegetation Management: Use of Reliability Centered Maintenance Concepts to Improve Performance. EPRI. Palo Alto, CA. 2009. 1019417.

APPENDIX 5.4

FUTURE COST TABLE
UNITIL-NEW HAMPSHIRE

5.4-1 Recommended Program Strategy Annual Cost (Option I): Seven-Year Hazard Tree Cycle and Moving Forward for Distribution with Sub-Transmission Cost[1]

VM Activity	(Budget Yr. 1-7)	(Budget Yr. 8-4)	(Budget Yr. 15-18)
Scheduled maintenance			
(Tree pruning/removal)	$1,246,000	$1,246,000	$1,246,000
Brush	$ 20,000	$ 20,000	$ 20,000
Mid-cycle	$ 138,000	$ 138,000	$ 138,000
Hazard Removal (7yr)	$ 800,000	$ 500,000	$ 300,000
Reliability Enhancement	$ 100,000	$ 100,000	$ 100,000
Un-scheduled	$ 40,000	$ 40,000	$ 40,000
TOTAL Distribution	**$2,344,000**	**$2,044,000**	**$1,844,000**
Sub-Transmission	$ 80,000	$ 80,000	$ 80,000
TOTAL VM PROGRAM	**$2,424,000**	**$2,124,000**	**$1,924,000**

5.4-2 Option II: First Hazard Tree Cycle and Moving Forward for Distribution with Sub-Transmission Cost[2]

VM Activity	(Budget Yr. 1-3)	(Budget Yr. 4-6)	(Budget Yr. 7-10)
Scheduled maintenance			
(Tree pruning/removal)	$1,246,000	$1,246,000	$1,246,000
Brush	$ 20,000	$ 20,000	$ 20,000
Mid-cycle	$ 138,000	$ 138,000	$ 138,000
Hazard Removal (7yr)	$1,755,000	$ 500,000	$ 300,000
Reliability Enhancement[3]	$ 0	$ 0	$ 0
Un-scheduled	$ 40,000	$ 40,000	$ 40,000
TOTAL Distribution	**$3,199,000**	**$1,944,000**	**$1,744,000**
Sub-Transmission	$ 80,000	$ 80,000	$ 80,000
TOTAL VM PROGRAM	**$3,279,000**	**$2,024,000**	**$1,824,000**

[1] Costs expressed in 2010 dollars. Represents annual cost associated with a 7-year hazard tree removal program.
[2] Costs expressed in 2010 dollars. Represents annual cost associated with a 3-year hazard tree removal program.
[3] With accelerated hazard tree removal there should not be a need for reliability enhancement.

APPENDIX 5.5

CONTRACTING STRATEGIES

UNITIL-NEW HAMPSHIRE

5.5 Introduction to Contracting Strategies

Three different approaches are commonly used by electric utilities to contract line clearance work. These include “time and material/equipment” (T&M), “unit price” and “firm price” or “lump sum” pricing strategies. Turnkey contracts can incorporate any of the other pricing strategies. Each has advantages and disadvantages that are important to understand and there are multiple variations possible within each pricing family. Each carries a different risk profile for the contractor and the utility. The following are brief descriptions of the common contracting strategies:

TIME AND MATERIALS (T&M)

T&M is normally the least risky for the contractor since most of the production-related risk is borne by the utility. T&M contracts with performance measures and incentives tend to move some of the production risk back to the contractor. T&M often results in the highest work quality. Poor performance may subject a contractor to contract termination or result in assignment of “penalty points” as part of future bid evaluations. For work that is highly variable in nature, difficult to quantify in advance and where quality and customers relations is a significant concern, T&M may be the most desirable method.

UNIT PRICE

Unit price work shifts production risk to the contractor, but requires preplanning by the utility to designate which units the contractor should complete. Units are normally a tree trimmed, a square area of brush removed, and a tree removed by diameter classes. There is a natural incentive for the contractor to provide only the level of quality enforced by the utility. Consequently, quality control inspection by the utility is an important administrative requirement for this pricing strategy as well as work completion inspection. Administration of unit price contracts can become burdensome for utilities with high tree densities.

FIRM PRICE

Firm price work shifts production to the contractor but also shifts work unit selection to the contractor. The natural incentive in this pricing strategy is for the contractor to select the minimum acceptable units and provide the minimum acceptable quality. Post-work inspection by the utility is critical to assuring that all work was completed in compliance with the established specification. Tree removal is often an issue in a firm price contract since costs for tree removal can be highly variable. Consequently, trees to be removed are sometimes identified in advance as part of the bid package preparation. Alternatively, unit prices by size class for tree removal can be established or tree removal can be completed on a T&M basis for trees specifically authorized by the utility. Firm price is best suited to situations where the work can be clearly defined and understood by the bidders. It should also be limited to locations where there will be good competition by a number of bidders. Awarding of concurrent firm price contracts to multiple contractors is desirable. Small firm price contracts bid to companies that do not have a local presence frequently results in higher pricing to cover the cost of per diems or personnel relocations necessary to establish a labor force

TURNKEY AND INCENTIVE BASED CONTRACTS

Turnkey pricing shifts the maximum risk from the utility to the turnkey service provider. This pricing strategy normally is accomplished by establishing incentives tied to accomplishment of specific objectives such as cost control, tree-related reliability targets, and customer relations. Because most of the program management responsibility is that of the contractor, it is critical that the utility closely monitor the performance objects through periodic review of key performance indicators. A variation of turnkey pricing is a management services contract with a third party management firm that administers contracts on behalf of the utility. The contracts for craft labor and equipment may continue to be with the utility or through the management company. The management services company may utilize any or all of the other pricing methods. This pricing strategy should be utilized if the utility has limited management resources, or desires to totally overhaul existing systems, methods and practices.

APPENDIX 5.6

NATIONAL ELECTRICAL SAFETY CODE
(NESC SECTION 218)
UNITIL-NEW HAMPSHIRE

National Electrical Safety Code (NESC)

Part 2: Safety Rules for Overhead Lines

218. Vegetation management

A. General

1. Vegetation that may damage ungrounded supply conductors should be pruned or removed. Vegetation management should be performed as experience has shown to be necessary.

   NOTE: Factors to consider in determining the extent of vegetation management required include, but are not limited to: line voltage class, species' growth rates and failure characteristics, right-of-way limitations, the vegetation's location in relation to the conductors, the potential combined movement of vegetation and conductors during routine winds, and sagging of conductors due to elevated temperatures of icing.

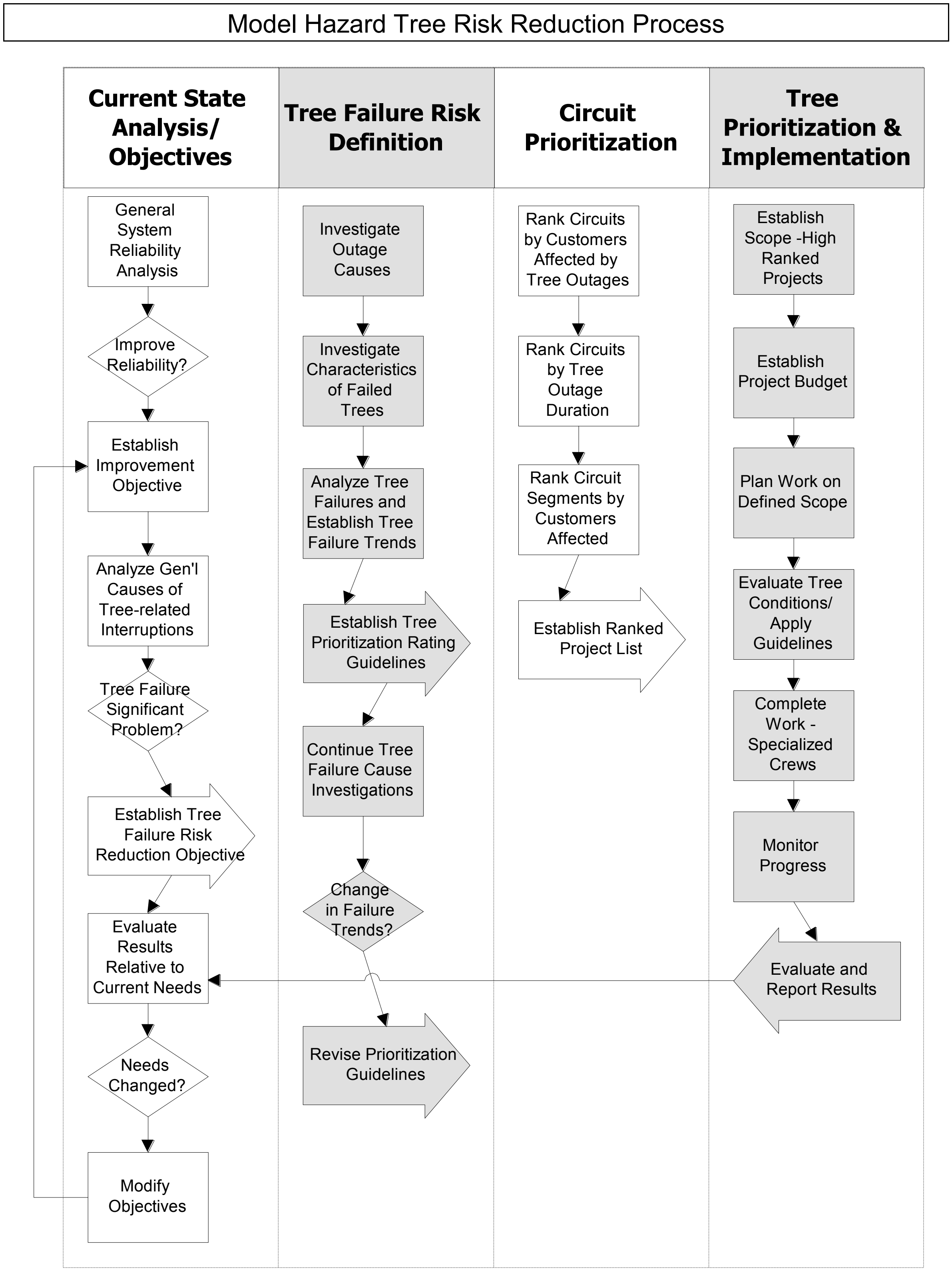
2. Where pruning or removal is not practical, the conductor should be separated from the tree with suitable materials or devices to avoid conductor damage by abrasion and grounding of the circuit through the tree.

A. At line crossings, railroad crossings and limited-access highway crossings

The crossing span and the adjoining span on each side of the crossing should be kept free from over-hanging or decayed trees or limbs that otherwise might fall into the line.

APPENDIX 5.7

MODEL HAZARD TREE RISK REDUCTION PROCESS UNITIL-NEW HAMPSHIRE


Model Hazard Tree Risk Reduction Process
Current State Analysis/ Objectives
Tree Failure Risk Definition
Circuit Prioritization
Tree Prioritization & Implementation
General System Reliability Analysis
Improve Reliability?
Establish Improvement Objective
Analyze Gen'l Causes of Tree-related Interruptions
Tree Failure Significant Problem?
Establish Tree Failure Risk Reduction Objective
Evaluate Results Relative to Current Needs
Needs Changed?
Modify Objectives
Investigate Outage Causes
Investigate Characteristics of Failed Trees
Analyze Tree Failures and Establish Tree Failure Trends
Establish Tree Prioritization Rating Guidelines
Continue Tree Failure Cause Investigations
Change in Failure Trends?
Revise Prioritization Guidelines
Rank Circuits by Customers Affected by Tree Outages
Rank Circuits by Tree Outage Duration
Rank Circuit Segments by Customers Affected
Establish Ranked Project List
Establish Scope -High Ranked Projects
Establish Project Budget
Plan Work on Defined Scope
Evaluate Tree Conditions/ Apply Guidelines
Complete Work - Specialized Crews
Monitor Progress
Evaluate and Report Results

APPENDIX 5.8

OUTAGE INVESTIGATION
UNITIL-NEW HAMPSHIRE

Tree-Caused Outage Investigation

Circuit: ________________
Voltage: _________________

Backbone / Lateral / Secondary / Service
(circle One)

Date of Outage: ____/____/_____
Time of Interruption: _________ AM/PM
# of Customers Affected: ___________
Duration: (hours/minutes)___________

Investigator: ________________
Date of Investigation: ____/____/_____
Circuit Last Trim Date: ____/____/____
Preventable? YES ____ NO ____

Location:
Street Address: ____
or
Street Name ____ and
Pole number where outage occurred: _______________________________
or
Street Name ____ and
Nearest intersection ____

Type of Outage:
___ Electrical Fault
Limb with carbon path found (yes or no)

___ Mechanical Failure - tree or part of a tree fell on the system causing outage.

Species: __________________________

Cause of Outage:
Limb fell
___ Small limb (< 4 inches)
___ Large limb (> 4 inches)

Tree fell
___ Major leader broke and fell
___ Trunk broke and fell
___ Tree uprooted and fell

___ Tree growth condition

Other
___ Not tree caused
___ Customer caused
___ Contractor activity
___ Beaver or animal activity
___ Undeterminable

Defect that Caused Failure
___ Codominant stem
___ Codominant stem with included bark
___ Cracks
___ Conks/fruiting bodies
___ Canker

___ Overhang
Decay
___ moderate
___ extensive
___ Dead

___ No causal defect observed
___ Other - describe below

Tree Location (point of tree failure)
___ Within the R/W limits
___ Beyond R/W limits
___ Top growth over line
___ Side growth at or above primary level
___ Side growth at or below primary level
___ Feet - distance from nearest primary

If tree uprooted - soil conditions
___ wet/saturated
___ shallow
___ sandy
___ other - describe

Protective device that operated
___ Substation breaker
___ 3-phase reclosure
___ 3-phase sectionalizer
___ 1-phase reclosure
___ 1-phase sectionalizer
___ 1-phase line fuse

Additional Comments: ____
____

APPENDIX 5.9

DRAFT–VEGETATION CONTROL POLICY

UNITIL-NEW HAMPSHIRE

Table of Contents

1.0 Policy Statement

The Unitil Vegetation Management Program:

- Ensures safe and reliable electric service for all Unitil customers while meeting or exceeding regulatory and governmental requirements and commitments.
- Drives reliability improvement through targeted program initiatives and strategic annual planning.
- Provides certainty in delivery to financial stakeholders by executing program objectives within budget.
- Shall proactively communicate with Internal and External stakeholders regarding program activities to maintain the long-term best interest of Unitil and its customers.
- Promotes the safety of its employees, customers, contractors, and the general public through enforcement of Unitil's safe work practices.
- Shall plan and execute every task in alignment with Unitil's Quality Assurance and Quality Control Program criteria.

2.0 Purpose

To establish a standardized vegetation management program for the Unitil system companies in order to insure consistency and the best practices approach in achieving safe and reliable operation of overhead Transmission and Distribution systems in accordance with Unitil's Strategic Plan.

3.0 General Policies

3.1 Customer Trimming Requests

Customer requested trimming requires careful assessment and management. These requests, if not handled properly, may result in a significant resource commitment both in terms of dollars and administrative labor without a proportional benefit to outage and/or damage prevention. In addition, improperly managed requests may result in negative customer sentiment.

Each request shall be individually reviewed by a Unitil representative in the field after a discussion with the customer reveals that a potential problem exists. Only those facilities that have significant contact with vegetation and pose an eminent outage condition shall be considered. "Like" tree conditions on adjacent line segments shall be taken into account and may warrant deferral of the customer trim request to full maintenance of that protected device. Deferral of the customer trim request shall also be considered where routine maintenance of that circuit is scheduled in the current program year. The customer shall receive notification as to the position of the company and shall also receive a complete explanation as to the decision.

3.2 Customer Notification and Permissions

3.2.1 Trimming Notification and Permission

In accordance with current State Laws, property owners shall be notified at least 45 days in advance of any scheduled maintenance tree trimming activities that may or will impact vegetation on their private property. Notification may include a mailer or other public notification as allotted under the Statute. Customers may "refuse" trimming on an individual basis by replying in writing to Unitil within 45 days of initial notification. Refusals shall be handled in accordance with Unitil's Refusal Policy. Unless otherwise refused in writing, customer permission for trimming and vegetation maintenance is automatically granted after the 45 days has expired. Permission for tree removal is not automatically granted and requires consent from the property owner.

Customer notification and permission is not required for restoration pruning or in cases where the vegetation poses an imminent threat to Unitil's facilities or to public safety.

3.2.2 Herbicide Notification and Permission

The certified contractor is responsible for all public and private notifications, customer permissions, permits, and fees associated with the application of herbicides on Unitil's transmission system. The contractor is solely responsible for knowing, understanding, and following all federal and state laws as well as local ordinances in regard to herbicide use and application. This includes any rules and regulations in regard to proper notifications.

3.3 Customer Complaint/Claim Process

Inquiries or claims from the public concerning activity by the vegetation contractor are the contractor's responsibility. Such inquiries or claims will be given to the responsible contractor's supervision for resolution. The contractor shall make initial contact with the customer on all claims issues within 24 hours. Contractor shall provide documentation of resolution of the customer inquiry within 7 calendar days. If the contractor's resolution is deemed unsatisfactory to the customer, the contractor shall notify the Unitil representative and provide just cause for their findings. The contractor shall report weekly to the Unitil Company Representative on the status of each claim.

3.4 Contractor Damage to Utility/Public/Private Property Procedure

The contractor shall make every effort to avoid damage to utility, public, or private property. The contractor is responsible for all damages caused by its employees or designated representatives. In the event damage occurs, the contractor will secure and make safe the area around the damage until repairs can be made. Damage to electrical facilities shall be immediately reported to the DOC. Damage to public or private property shall be reported to the property owner immediately. The resolution of the damage shall follow the same process as in *Section 3.3 Customer Complaint/Claims Process.*

3.5 Refusal Process

A refusal is defined as any refusal by a customer to:

1. Access the property and/or allow the contractor to perform line clearance.
2. Obtain proper clearance as outlined in *Section 6.0 Clearance Zones/Standards*, or fail to allow trimming per A-300 guidelines.
3. Allow contractor to remove a hazard tree deemed to be critical.

Refusals received in writing as part of the normal customer notification process will be reviewed and followed up by the DOC or assigned to a contractor Supervisor/General Foreperson for investigation and initial customer contact.

The contractor Supervisor/General Foreperson shall be responsible for addressing customer refusals when encountered during the execution of the assigned work. The primary objective will be to educate the customer on the benefits and needs for Unitil to perform vegetation clearing on their property and to secure permission to proceed. If the contractor Supervisor/GF is unsuccessful in securing permission, the refusal shall be duly recorded and forwarded to the DOC for further review and action.

3.6 Intercompany Operating Procedures

The purpose of the Intercompany Operating Procedure (IOP) is to establish a definite method of allocating costs of trimming associated with both construction and maintenance of joint pole lines.

Maintenance trimming shall be done on a joint basis. This joint participation is dependent upon the individual IOP's established with each telephone company however the division of costs are typically either 75% Unitil and 25% telephone or 80% Unitil and 20% telephone.

Heavy storm work shall be handled immediately without prior review. The parties agree to a reciprocal acceptance of each other's tree contractors for heavy storms on a 50%/50% basis, provided field representatives, as soon as practicable after a major storm, meet to communicate cities/towns, streets, and lines trimmed as a result of said storm. Subsequent bills to include the same information.

Lastly, removal of danger trees including large limbs that threaten both parties' facilities shall be removed on a 50%/50% basis, subject to prior field review wherever possible (see Section 7.6 of this Operating Bulletin).

4.0 Trimming Cycles

4.1 Cycle(s)

4.1.1 Voltage and Phasing Considerations

Transmission and Distribution vegetation control shall be completed on a cycle according to the following voltage and phasing classes:

Voltage Class	Cycle		
	Three Phase	**Single Phase**	**Other**
4 kV	8 years	10 years	---------------
13.8 kV	5 years	7 years	---------------
34.5 kV	4 years	5 years	---------------
34.5 kV Sub Tran	---------------	---------------	5 years
>34.5 kV Trans	---------------	---------------	5 years

Services shall be reviewed for trimming on the same cycle and concurrently to the distribution primary circuit. For the purposes of record keeping and metric evaluation, services and secondary pole lines trimmed shall be categorized as unscheduled work.

5.0 Circuit Selection, Scheduling, and Planning

5.1 Circuit Selection

5.1.1 Distribution Circuit Selection

The determination of the amount of distribution trimming shall be calculated based upon the pole miles of distribution circuits, by voltage class and phasing, excluding secondaries and services. The total miles by voltage class and phasing shall be determined based upon the annual statistical report compiled by individual distribution operation centers (DOCs). The total annual miles to be selected for each voltage and phasing classification will be determined as follows:

Annual *miles selected = class mileage / cycle length*

For example, if the mileage for 4 kV Three Phase and Single Phase is determined to be 199 and 215 respectively, then the annual mileage to be trimmed for 4 kV is as follows:

4 kV Three Phase miles to be trimmed = 199 miles / 8 years = 24.88 miles
4 kV Single Phase miles to be trimmed = 215 miles / 10 years = 21.50 miles

The actual circuit selections for each classification shall be based upon targeting the oldest last trim date circuits first and continuing to select the oldest circuits until the mileage commitment for that classification has been met.

In addition to the circuit miles selected to meet cycle targets, Engineering may select additional poor performing circuits or line sections to be trimmed with the ultimate objective of improving the System Average Interruption Duration Index, or SAIDI. This analysis shall be completed during the annual capital budgeting process. Operations shall endeavor to complete these additional selections as early as possible in the fiscal year so that the SAIDI benefit may be realized as soon as possible.

5.1.2 Transmission Circuit Selection

Transmission vegetation control shall be completed on a 5-year cycle. This results in the maintenance of one-fifth of the transmission system on an annual basis. The determination of the amount of trimming may be calculated based upon the pole miles of transmission line or acreage. Since many of our rights-of-way have more than one line, and because many rights-of-way can accommodate more than the existing facilities, the preferred unit of measure shall be acres. The acres unit of measure accommodates varying line configurations as well as varying widths of right-of-way. Therefore all planning and reporting of transmission vegetation control shall utilize acres as the standard unit of measure. Transmission circuits shall be selected based upon targeting the oldest last trimmed circuits first that equal one fifth of the total system transmission mileage.

5.2 Scheduling

Circuit reliability shall be used to prioritize and schedule the pre-selected circuits due on cycle. On an annual basis, Unitil Engineering shall review reliability performance on a circuit by circuit basis. System Average Interruption Duration Index (SAIDI or SU) and System Average Interruption Frequency Index (SAIFI) are the two main metrics used for this analysis. Operations shall use this information to develop the trimming schedule for the year.

5.3 Pre-Planning

5.3.1 Trimming – tree selection: On/Off/Beside ROW

Pre-planning is critical in determining the volume of maintenance trimming work required to execute the annual maintenance cycle plan. This information will be used to estimate resource needs and to estimate costs. More importantly, proper pre-planning will help to maximize reliability savings by identifying those on/off right-of-way trees that should be pruned to prevent tree related outages.

Prior to budgeting, circuits or areas to be trimmed shall be field inspected. Relative vegetation density (light, medium, heavy) shall be recorded. Particular attention shall be granted to inspecting trees outside of the right-of–way. A majority of the single phase outages can be attributed to line contact caused by off right-of-way trees. Off right-of-way trees that may contact the facilities prior to the next cycle shall be noted and trimmed during the current maintenance cycle.

The work planner shall focus on identifying those off right-of-way trees with obvious or suspected defects that may cause the branches or tops to fail and make line contact. Refer to *Section 7.6 Danger and Hazard Trees* for more info. These defects may include:

- dead branches or tops
- declining or atrophied branches
- large cat faces or trunk rot
- large co-dominant stems with included bark
- weekly attached limbs or sucker growth from prior improper pruning

In each case, the branch or tree crown shall be reduced to eliminate the potential threat. If the branch or crown cannot be effectively reduced within the ANSI A-300 standards, the tree shall be removed pending property owner permission.

5.3.2 Removal Selections and Permitting: On/Off/Beside ROW

The work planner shall identify areas of opportunity within the right-of-way to remove fast growing trees to prevent future grow-ins and to reduce future line maintenance costs. In addition, the work planner shall also focus on off right-of-way trees that may have the potential to experience catastrophic failure due to an identified defect. If the defect cannot be corrected through proper pruning, that tree shall be identified as a removal candidate. The identification and elimination of these Danger and Hazard Trees is crucial to preventing interruptions. Trees with more than two-thirds crown die back and/or severely declining trees should be removed. Trees with a lean of greater than 45 degrees from vertical shall also be considered for removal. Less obvious defects that may result in tree failure are related to root decline. The planner shall note any heavy construction or trenching around off right-of-way trees that may have damaged the trees root system. Trees with damaged root systems are prone to catastrophic failure at the base and must be removed to prevent damage to Unitil facilities.

The work planner shall make every effort to contact the property owner to secure removal permission for those identified removal candidates on private property. Where permission is not readily obtained, the pending list shall be forwarded to the DOC Manager to assign as follow up to a Unitil representative. Removal refusals shall be documented for auditing purposes.

6.0 Clearance Zones/Standards

6.1 Services

6.1.1 Open Wire Service Drops

Minimum clearance normally shall be two (2) radial feet. If the existing clearance is less than two (2) feet between a tree trunk, leader, or large limb and conductors, remove all other small branches within two (2) feet all around the conductors. If a tree trunk or large limb is rubbing against conductors, report the condition to Unitil for a decision as to whether tree work or line work will be performed to correct the condition.

6.1.2 Secondary Cable Service Drops

During scheduled maintenance, all services will be inspected along trim route and any service where there is evidence of hard rubbing should be trimmed to a minimum of two (2) feet all around to prevent chafing which could cause cable failure.

Service trims should be performed by one crew member while the other is performing other ground work such as re-positioning the bucket truck or doing paperwork. However, each crew member shall be within visual and verbal contact of the other at all times in order to maintain safe work practices.

6.2 Distribution (4 kV – 34.5 kV)

6.2.1 Primary and Open Wire Secondaries

The tree position (relative to the wires), species and condition of the tree determine the type of trimming required. It is the contractor's responsibility to be knowledgeable about and to instruct his crews in various techniques necessary for trimming individual trees. Clearance shall be sufficient all around the primary and open wire secondary conductors to keep them free of tree contacts for at least five (5) years. In cases of ornamental trees, care must be taken when trimming and done in a manner that the final shape of the tree is evenly proportioned.

The goal of distribution vegetation control is to limit the opportunity for the tree contact while trimming a reasonable volume of vegetation. Minimum conductor clearances relative to various primary and open wire secondary positions are shown in the table below and in Figures 1 and 2 (Appendix C).

	Multi-Phase	Single Phase
Clearance above primary conductor	15 foot minimum plus danger trees and dead wood	6 foot minimum above plus danger trees and deadwood
Clearance adjacent to primary conductor	8 foot minimum plus 20 foot minimum clearance for danger trees and deadwood	6 foot minimum plus 20 feet minimum clearance for danger trees and deadwood
Clearance below lowest attachment point on pole	Ground cut or the greater of four (4) feet below lowest telephone cable or 10 feet below primary conductors/open wire secondaries	Ground cut or the greater of four (4) feet below lowest telephone cable or 10 feet below primary conductors/open wire secondaries

The specifications listed above shall be strictly followed. However, it is recognized that, from time to time, proper permission may not be granted from property owners. In addition, scenic road designations may preclude the achievement of specified clearances. Permission problems and/or scenic road designations shall be well documented on the daily timesheets (See *Section 8.3, Contractor Daily Timesheet Information*) for auditing purposes.

If the existing clearance is less than the minimum required clearance between the tree trunk or large healthy limb (with strong crotch attachment) and wires, leave them and remove all other branches within the minimum clearance zone.

6.2.2 Line Extensions: Private Property

A) Before the initial installation of wires, maximum efforts shall be made to remove all tree species in a trip centered on the new pole line as follows:

Single phase primaries and/or secondaries:
10 feet each side of pole line center

Three phase primaries:
14 feet each side of pole line center

B) Outside of the defined trip, tree removal and tree trimming shall be performed as necessary to conformance with the major articles immediately following.

C) NOTE: Line clearing for the initial installation of overhead conductors in a development or on private property shall be paid for or provided by the developer or customer and the tree contractor shall be advised accordingly.

6.2.3 Line Extensions: Public Way

A) Follow Inter-Company Operating Procedure (IOP) with applicable telephone company.

6.3 Sub/Transmission (34.5 kV Sub and > 34.5 kV)

Clear cutting or the removal of all vegetation at ground level, shall take place on all areas of the right-of-way except when prohibited in environmentally sensitive areas (such as wetland or exception areas) or in some land restricted areas. In these situations, Unitil shall apply the following minimum clearances to vegetation.

Unitil establishes the following minimum transmission clearance to vegetation in accordance with NERC Standard FAC 003-01.

Clearance 1 - The minimum clearance distances to be achieved at the time of transmission vegetation management work (when clear cutting is not an option) shall be based on the minimum approach distances as defined in Table 2 of ANSI Z133.1-2006.

Table 2. Minimum approach distances to energized conductors for persons other than qualified line-clearance arborists and qualified line-clearance arborist trainees.

Nominal voltage in kilovolts (kV) phase-to-phase*	**Distance**	
	feet-inches	meters
0.0 to 1.0	10-00	3.05
1.1 to 15.0	10-00	3.05
15.1 to 36.0	10-00	3.05
36.1 to 50.0	10-00	3.05
50.1 to 72.5	10-09	3.28
72.6 to 121.0	12-04	3.76
138.0 to 145.0	13-02	4.00
161.0 to 169.0	14-00	4.24
230.0 to 242.0	16-05	4.97
345.0 to 362.0	20-05	6.17
500.0 to 550.0	26-08	8.05
785.0 to 800.0	35-00	10.55

* Exceeds phase to ground. Per 29 CFR 1910.333

ANSI Z133.1-2006: Table 2

Refer to Appendix F for further detail relating to Transmission Clearance Standards (particularly Clearance 2 specification for maintaining clearance) and Danger/Hazard trees identification and maintenance.

7.0 Maintenance Practices

7.1 Industry Standards and Best Practices: ANSI A300 (Part 1 and Part 7)

All tree work shall be performed in accordance with the current ANSI-A-300 for Tree Care Operations Part 1 and Part 7. In addition, Supplier shall follow the principles outlined in the **Best Management Practices- Utility Pruning of Trees** special companion publication to the ANSI A-300 standards.

7.2 Pruning

Pruning is the selective removal of plant parts to meet specific goals and objectives. Where necessary, contractors will be required to prune or trim vegetation in direct conflict with Unitil's facilities per the guidelines set forth in this document. Utility pruning may be classified into 5 categories:

1. **Through Pruning** – is utilized for large trees located directly beneath the energized conductors in which branches are removed within the crown to allow lines to pass through the tree. Cuts should be made at crotches to encourage growth away from the lines.
2. **Overhang Pruning** – is the removal of limbs hanging over the top of the energized conductors. When trees are of sufficient height and lines are directly underneath, it is necessary to elevate limbs to the appropriate clearance. All dead limbs should be removed over the primary wire regardless of height.
3. **Under Pruning** – or crown reduction is achieved by cutting back portions of the upper crown of the tree. This is often required when a tree is located directly beneath the conductors. The main leader or leaders are cut back to a suitable lateral.
4. **Side Pruning** – consists of cutting back or removing the side branches that are threatening the conductors. Side pruning is required where trees are growing adjacent to utility lines. Limbs should be removed at a lateral branch or the main trunk. Proper side trimming of conifers will often minimize or eliminate the need to trim them in future cycles..
5. **Ground to Sky** – side pruning or removal of all limbs vertically from the ground up at some pre-determined horizontal distance from the energized conductors.

The contractor is responsible for the proper training and instruction of its employees in the safe removal of tree limbs under each scenario.

7.3 Mechanical Pruning

Wherever practical, mechanized equipment shall be used to reduce trimming costs. Mechanical pruning refers to the use of specialized equipment to prune or trim limbs under and adjacent to the electrical facilities, without deploying an individual to manually remove the limbs with a chain saw. This specialized equipment may includes an articulated boom affixed with multiple circular blades (i.e. Jarraff) or in some cases, a flail mower head mounted to a boom. Not recommended for overhang pruning.

7.4 Mowing/Mechanical Clearing

Mowing is defined as the mechanical removal of vegetation using various motorized apparatus that may be attached to off-road equipment. Mowing is a cost effective means of vegetation control on transmission rights-of-way particularly when herbicide applications may be an issue. The topography must be free of rivers and large streams since the equipment is unable to cross such obstacles. Several vendors have become proficient in this method and Unitil has contracted with them with favorable results.

7.5 Herbicides

7.5.1 Herbicide Selection

The spraying of herbicides by certified contractors has shown to be a cost effective vegetation management tool. Increased regulation in this area has resulted in an increased administrative burden. However at this time the additional responsibilities have not outweighed the resulting benefits. Therefore this method continues to be a preferred method of transmission vegetation control for Unitil Companies.

The certified contractor shall be responsible for the proper selection and application of herbicides per manufacturers' label. The contractor shall select the herbicide and treatment method that best accomplishes the overall program goals for the transmission right-of-way maintenance program. Low volume foliar, high volume foliar, basal, and cut stump treatment are all valid treatment methods.

Herbicide applications are not practical for all applications. For example, rights-of-way that include a large percentage of farmlands, or rivers/streams may not be conducive to herbicide use. However for many applications, herbicide use continues to be an efficient, cost-effective method of controlling growth along Unitil's rights-of-way.

7.5.2 Record Keeping

The certified contractor shall be responsible for keeping and maintaining all records in regard to herbicide application on Unitil Companies properties and rights-of-way. These records must meet the minimum requirements as mandated by federal, state, and local laws. These records shall be provided to

Unitil as part of the invoicing process. The records shall be clearly identifiable as to transmission circuit, location, herbicide type, and amount used.

7.5.3 Property Owner and Public Notification

The certified contractor shall be responsible for all notification, permit, and fees associated with herbicide application on the Unitil Companies system. All herbicide will be used in accordance with label requirements and all other local, state, and federal regulations.

Because laws between Massachusetts and New Hampshire could vary, this Operations Bulletin will not address one specific method. Instead the bulletin will outline the steps currently utilized by one New Hampshire DOC. These steps are as follows:

1. Obtain herbicide permit from the NH Department of Environmental Services. This is the responsibility of the certified contractor performing the herbicide application.
2. By means of certified mail, notify the selectmen, mayor, or town manager in the city or town where the rights-of-way are located (refer to Appendix A for a copy of the sample letter).
3. Notification to the public through the use of notices in one newspaper of statewide circulation and in all newspapers of local circulation (refer to Appendix B for copy of sample notice).
4. Notification through billing stuffers, by telephone, or in person each abutter along the right-of-way where herbicides are to the applied. Abutters shall be offered alternative vegetation management, i.e. mechanical clearing. This is New Hampshire state law (RSA 374:2-a) and the wishes of the landowner shall take precedence.
5. Posting signs every 200 feet along the perimeter of the right-of-way where herbicides are to be applied.

New Hampshire State Law further stipulates the format of the newspaper advertisements, including specific information required for publication as well as a requirement that the advertisement be a “coupon” that may be clipped and mailed back to the utility.

The information provided in the Operations Bulletin shall be used as a guideline only and is **not intended to be all-inclusive**.

7.6 Danger and Hazard Trees

Danger trees are defined as any tree, healthy or otherwise, that is of sufficient height and proximity to the conductors that should it fail, has the potential to contact/damage the electrical facilities. Danger trees shall be identified on transmission circuits during the execution of the transmission cyclical plan and shall be addressed at that time.

Hazard trees are defined as dead, dying, or otherwise defective trees or limbs that pose a threat to distribution or transmission circuits upon their failure. By default, a hazard tree is also a danger tree. Hazard trees may break away at any time, fall into the circuit and result in damage to Unitil Company facilities. A list of these defects may include:

- Poor quality of branch or scaffold structure
- Past failure
- Excessive lean
- Cabling or other support structure
- Decay, cavities, wounds, or pests
- Lack of basal flair or trunk taper
- Large cat faces, hollows, or trunk rot
- Presence of trunk cracks
- Included bark
- Excessive limb weight or size relative to parent stem
- Cracked or broken limbs
- Dead or decayed limbs or crown

Managing hazard trees requires identification and immediate correction. Methods for resolution include removal of the entire tree, or removal of the problem branches or tree section. The objective is to ensure that if the tree fails, the integrity of the distribution/transmission circuit will be maintained.

The work planner shall identify, permission, and recommend removal of danger and hazard trees during the pre-planning process. The line clearing contractor shall also be responsible for identifying, permissioning, and correcting danger and hazard trees during the execution of the assigned distribution/transmission circuit work.

Third party participation shall be pursued in all distribution danger or hazard tree removals prior to commencement of the program. Participation is based upon the current Intercompany Operation Procedures as detailed in *Section 3.6* of this Operating Bulletin. Reimbursement provides significant payment to Unitil allowing for further funding of the Vegetation Management Program. Refusal of participation shall be properly documented.

7.7 Vine Removal

Vines growing on a facility shall be cut at the base of the facility (i.e. pole or guy wire). Extensive vine conditions that engulf energized facilities shall be cut, but also referred to Unitil for removal to prevent dead vine caused interruptions. Vines attaching to poles from trees above the ground line shall also be cut as appropriate. Vines shall never be pulled off energized facilities when at or above the energized equipment.

8.0 Vegetation Management Program Metrics

In order to measure the effectiveness of the trimming program, data shall be collected on a continuous basis and performance metrics shall be calculated and published by the DOC, on the Operations System web page. Comparative analysis shall allow for continued improvement in vegetation control methods and techniques. Responsibility for the collection of data, accurate and timely reporting, and comparative analysis shall rest with the DOC's respective Manager of Electric Systems or their designee. Performance metrics shall be updated no less that once per month.

8.1 Effectiveness Measures

To monitor the effectiveness of the transmission trimming program, each DOC shall record the total number of momentary or permanent outages experienced on the Unitil transmission system on a monthly basis. Only those momentary and permanent outages related to tree or limb contact are utilized for the metric. Additionally, only those trees and limbs that are within the trim zone shall be included. The metric is expressed as follows:

Transmission Effectiveness = Total number of momentary or permanent outages

The logic behind the measure is that an effective transmission trimming program shall have the objective of minimizing these types of interruptions.

In order to monitor the effectiveness of the distribution trimming program, each DOC shall record the **number of tree-related outages, by voltage class**, on a monthly basis. This number shall be divided by the **total number of pole miles per respective voltage class** in the DOC as described in *Section 6.2.1*. The quotient, expressed as follows, shall comprise the effectiveness measurement for distribution vegetation control:

$$\text{Distribution Effectiveness} = \frac{\text{Number of tree-related outages (by voltage class)}}{\text{Total number of pole miles (by voltage class)}}$$

The logic behind the measure is that an effective trimming program shall have the objective of minimizing tree-related outages.

8.2 Efficiency Measures

Efficiency metrics are designed to compare costs and ensure that resources are deployed in a manner that achieves the greatest amount of trimming for the dollars expended.

For Transmission efficiency, each DOC shall record **dollars expended** and **acres maintained**. The quotient, expressed as follows, shall comprise the effectiveness measurement for transmission vegetation control:

$$\textit{Transmission Efficiency} = \frac{\textit{Total dollars expended}}{\textit{Total acres maintained}}$$

For Distribution, each DOC shall record **dollars expended** and **section of primary conductor trimmed**. The quotient, expressed as follows, shall comprise the effectiveness measurement for distribution vegetation control:

$$\textit{Distribution Efficiency} = \frac{\textit{Total dollars expended}}{\textit{Number of sections trimmed}}$$

The **number of sections trimmed** shall also include services. In other words, one service is equal to one section.

The logic behind this measurement is that the most efficient crews shall be more productive and able to achieve the lowest cost per section of circuit trimmed.

8.3 Monthly reports & Map Updating

Monthly progress reports shall be available. These reports shall provide specific information regarding the status of individual DOC vegetation management programs. Information shall include annual schedules for transmission and distribution programs, scheduling status, and performance metrics. The report will be completed by individual DOC's and then rolled into one single, Unitil system report. Please see Appendix E for format of report.

It shall be the responsibility of the Manager, Electric Systems or their designee to update the Operations System web site no less than once per quarter. In addition, each DOC shall utilize circuit maps as a means to track circuit trimming. The maps shall detail the specific locations that our facilities were trimmed along with appropriate dates. These maps shall remain on file for at least one complete cycle.

9.0 Vegetation Management Budget

Transmission and Distribution trimming budgets shall be completed annually based upon the scheduled cycle, volume of trimming, as well as an estimate of unscheduled work.

9.1 Annual Program Cost Estimating Process

Annual costs shall be based upon the volume of work required for that cycle year and the amount of expected trimming, including both the scheduled and unscheduled work. Cost estimating is comprised of four primary components:

1. **Volume** – density of work relative to trees per mile or other criteria (i.e. light, medium, heavy). Used as a sub component of Cost to determine proper cost tier to use in budget estimate.
2. **Prescription** – type or method of maintenance. I.E. pruning, herbicide, mowing, etc. Also a sub component of Cost.
3. **Amount** – number of pole miles (Distribution), acres (Transmission), or number of tickets (Restoration, Customer Trim Requests, Hot Spot Requests, etc).
4. **Cost** – estimated maintenance cost per mile, cost per acre, or cost per ticket. Cost may be stratified by volume and prescription.

Prior to the budget cycle, it is necessary to properly estimate the Volume and Prescription for each acre (Transmission) and each pole mile (Distribution) to be maintained in the budget planning year. This inspection or estimation shall break down the Amount of work by the Prescription method and Volume to ensure proper cost pers are utilized. Non-scheduled work shall be estimated using historical data to determine anticipated volume. This includes an estimated ticket count for Customer Trim Requests, Emergency Work, and Hot Spot Requests.

9.1.1 Determining Volume of Work

In order to determine the Volume of work, the amount of vegetation growth needs to be established. The type of clearing (light, medium, and heavy) can only be determined by field inspection. Prior to budgeting, the circuits/areas to be trimmed shall be inspected to determine the vegetation growth density. The information from this inspection shall then be utilized to calculate required resources for the budget cycle year as well as to determine proper costs to be used in the budget calculations.

In an area where it is anticipated that work shall be placed out to bid, Unitil shall endeavor to perform such bidding in advance of the actual budgeting process. This will allow for more accurate budgeting.

9.1.2 Determining Prescription

During the field inspection, opportunities to reduce line clearance costs through proper prescription shall be a priority. Significant savings may be obtained by converting manually pruned miles to mechanical. Long term savings can be realized through extended herbicide use vs. mowing. Danger and Hazard trees as well as critical removals shall be part of the prescription and captured in the overall budget estimate. Accuracy is important in selecting the proper prescription since each maintenance method may have a different cost to implement.

9.1.3 Determining Amount of Work

Determining the amount of work to be performed for scheduled work during the budget cycle year is determined by the number of distribution pole miles and transmission acres due on cycle. Refer to *Section 5.1* of this Operating Bulletin for further information in determining annual cycle miles to be maintained.

Non-scheduled work volume shall be estimated using historical data to determine anticipated volume for the budget cycle year. This includes an estimated ticket count and cost for Customer Trim Requests, Emergency Work, and Hot Spot Requests.

9.2 Budgeting Non-Scheduled Work

Non-scheduled work shall be estimated for budgeting purposes, based on historical or past quantities and costs.

9.2.1 Hot Spotting

From time to time "hot spot" trimming (unscheduled work sections) is required due to tree contact and or multiple outages as a result of trees. This usually happens off cycle as a result of increased vegetation growth or non-compliance with standards during normal cycle maintenance.

It is important that hot spot trimming be carefully managed as this practice is inefficient and results in increased costs. It is recognized that hot spot trimming is a necessary part of vegetation control, but its use shall be minimized to the extent possible.

9.2.2 Customer Trim Requests

Customers may request Unitil to perform vegetation work at their specific property, outside of the normal cycle. This can include requests for dead tree removal, service trimming, or topping of specific trees to make safe for customers to remove. Customer Trim Requests (CTR's) shall be deferred whenever possible. As a general rule, Customer Trim Requests have little or no impact on improving service reliability. Each request shall be individually reviewed in the field to determine the validity and need of the request.

Deferring Customer Trim Requests to routine maintenance allows for better budgeting and cost savings in terms of future maintenance that can be performed for the same budget dollar. See *Section 3.1* of this Operating Bulletin for additional information.

9.2.3 Emergency Work

Tree crews shall be required to assist with outage restoration throughout the year. This will include restoration support during normal working hours as well as after hours. It is important that the OT premium for after hour's restoration be included in any budget estimates. Historical data shall be the driver in estimating restoration expenses.

9.2.4 New Construction Work

New construction also includes: major system improvement work, system expansion work, and other "Capital" work. It is generally budgeted at the Operations level and as such normally falls outside of the vegetation maintenance budget. However, it is important to estimate the amount of new construction work in order to properly estimate resource needs for the budget cycle year.

9.3 Competitive Bidding

Circuits, line sections, or Transmission acres planned to be competitive bid, shall be identified prior to the budget preparation cycle and budgeted separately. Every effort shall be made to complete bidding prior to budgeting to allow for a more accurate budget estimate.

Competitive bidding is an effective method for performing either maintenance trimming or construction trimming. Not all work is conducive to bidding. In most cases, the best utilization of competitive bidding is for work that is confined to a defined scope. Work to be considered for competitive bidding includes:

- Complete circuit trimming
- Off-road trimming where specialized equipment is needed
- Long line extensions along public way
- Major system improvements such as voltage conversions
- Specialty work (mowing, herbicide application, mechanical pruning)

Competitive bid documents shall be developed to request various different staffing alternatives. Three different approaches to bidding shall be used:

1. Per circuit – Not to exceed cost
2. Per hour cost (T&E) based upon known schedule
3. Alternative approach
    a. Minimum of 1 crew on site bid on a per hour cost
    b. 1 crew on site as required bid on a per mile basis

Considerations should be given to limit the age of equipment used by the contract tree crews. Alternatively, maintenance (i.e. repair) time for contract tree equipment should not be included in the bid.

9.4 Inter-Company Operational Cost Sharing

Cost sharing as per the IOP can offer significant budget savings which can be re-applied to other maintenance activities. Refer to *Section 3.6* of this Operating Bulletin for more information.

9.5 Vendor Selection

Criteria for vendor selection shall be based upon cost and performance. It is also strongly recommended to select a vendor that is able to provide additional resources during storm events.

On a routine basis, Unitil shall solicit requests for proposals from local tree contractors. These proposals shall include a listing of personnel and equipment, along with any ancillary services the vendor may provide. Other selection criteria include the safety record of the vendor and minimum insurance requirements as set forth in Unitil Policies. The DOC management will then evaluate the proposal and select an appropriate vendor.

10.0 Supervision

10.1 Unitil

The Manager, Electric Systems or their designee shall be responsible for developing schedules and monitoring the progress of said schedules. The Manager, Electric Systems, shall be responsible for monitoring the efficiency and effectiveness of the contract crews, ensuring that their productivity and quality are as expected.

Any knowledgeable DOC employee may perform monitoring of the contract crews. Monitoring includes live field visits and post-audit inspections. The results of these field visits and audits shall be reported to the Manager, Electric Systems.

10.2 Contractor

The contractor shall provide adequate supervision and direct oversight of its employees and work being performed at all times. Contract supervision shall be responsible for all aspects of the work being performed. The contract supervisor shall also be responsible for reporting work progress to the assigned Unitil representative.

11.0 Line Clearing Contractor

11.1 Quality Assurance

Unitil requires that work units issued to the vendor be verified for quality and completeness of work. It is the vendor’s responsibility to document refusals, insufficient clearance, and any other customer-driven exceptions that do not comply with Unitil's line clearance specifications. The accuracy of mapped work units should also be verified to ensure reliability of work units. To support Unitil’s expectation that completed work will increase the reliability of the corresponding distribution device; the vendor shall verify that current field switch positions and/or additional new line segments correspond to the primary maps issued for maintenance. Any discrepancies should be reported to the Unitil DOC as soon as possible.

The contractor shall have a quality assurance program in place with quality control procedures documented. Unitil Company Representatives will audit completed work to verify acceptance of work and quality of work.

All work units must be certified as completed by the contractor and submitted to the Unitil Rep within 10 days of work completion. It is mandatory that the entire work unit or site is field checked by the contractor and certified complete before Unitil performs the final inspection.

The Unitil representative will review completed work for compliance to work scope, work specification, and quality within 30 calendar days of completion and receipt of the completed work package. Any resulting deficiencies found will result in rework which will be returned to the contractor for correction. The vendor shall complete any reworks within 30 calendar days. Contractor shall re-notify customers as required when scheduling reworks.

11.1.1 Contractor Quality Defects

The following is a description, by category, to familiarize the contractor with the expectations of Quality Control & Compliance while performing a quality inspection on completed Planned Maintenance work. Our goal is to identify defective work that does not meet Unitil Companies specifications and/or as defined by the contract. These defects fall into two categories:

Actionable Defects (rework required): Issues that do not conform to specifications and have high potential to pose within-cycle reliability issues or high potential to directly affect the customer in a negative manner. These issues will generate a rework.

Non-Actionable Defects (no rework required): Issues that do not conform to Unitil specifications, but will not affect system reliability and have a lower potential to directly impact the customer. This category may also define defects that cannot effectively be corrected, such as A-300 infractions (i.e. flush cuts). These issues will not generate a rework, but should be used as a training opportunity to avoid future occurrences.

11.1.2 Defect Categories

Insufficient Clearance: A defect will occur when the clearance obtained is not sufficient to maintain cycle length in a situation where more appropriate clearance could have been provided (i.e. not enough pruning took place to clear the facilities for the cycle).

Exceptions may exist where healthy terminal leads or branches remain within the clearance zone. Examples are mature oak leads or branches with no lateral branches in clearance zone, or mature low-growth trees that will never reach conductor height but are within trim zone.

QA will always take into account species specific clearance when determining if clearance is appropriate.

Generally, the only acceptable cause for an insufficient clearance defect is a customer issue. In this case, the Unitil representative will evaluate the work packet to determine if a contractor documented refusal for the location was noted on the timesheet and/or submitted with the final work package.

A-300 Defects: All work shall be performed in accordance with ANSI A-300 for Tree Care Operations. The Unitil representative will document defects that do not conform to this standard. The defect may fall into one of two categories:

1. Actionable A-300 Defects (rework): If A-300 defects are consistent throughout the entire sample area, the vendor will be asked to return and correct all A-300 defects for the entire work unit. If any A-300 defects are observed in known political / customer sensitive areas, the locations will be documented and the vendor will be asked to return and correct all defects in the work unit to avoid customer issues (if correctible).
2. Non-Actionable A-300 Defects (no rework): A-300 defects that do not appear to be a consistent problem (individual location) and / or appear in lower visibility areas, will not require rework if the customer does not complain. However, the defects will be documented as a training opportunity. This method promotes A-300 practices, but does not involve the additional cost associated with reworks.

Practices / Defects to Avoid:

- Stub Cuts: Avoid by removing branches as close to the trunk or parent limb as possible without cutting into the branch collar or bark ridge.
- Flush Cuts: Avoid cutting below or into the collar.

- Heading Cuts: Should only be made on species that present no other option due to rapid, multi-stem growth, when removal of the tree is not practical or possible.
- Non-essential Pruning: Pruning of trees that will not affect the facilities within cycle due to species characteristics, distance from the facilities, and / or site condition.
- Extreme Pruning: Pruning that essentially destroys the tree to in order to gain proper clearance. An attempt should be made to contact the customer and remove the trees with owner consent.

11.1.3 Contractor Quality Expectations

Hazard Tree: All dead / declining / damaged / excessively leaning trees that endanger Unitil Distribution or Transmission facilities must be removed or topped below the facilities. Any standing Hazard trees at the time of the Quality inspection will result in rework.

The expectation is that the vendor will use the most cost efficient method to make the tree safe, given the immediate surroundings and site condition. Any customer refusals must be documented and referred to the DOC immediately.

Vines: All live vines encountered on a work unit which are growing on or into Unitil facilities should be cut. Failure to address vines will result in rework. This includes vines that are growing onto facilities from trees above the conductors.

Debris: The expectation is that the vendor will dispose of all woody debris created unless the site clearly presents itself for on-site chipping or mulching and local ordinance allow. This should be evident by the site condition, location, and visibility. Alternative methods, such as fly-chipping, cutting / scattering, and stacking cuttings may be acceptable if the site is adequate or an agreement is made with the customer.

Removal Expectation: The contractor will identify and permission all Danger (on Transmission) and Hazard trees for removal. Identified Danger and Hazard trees not removed or without a valid customer refusal, shall be returned to the contractor for follow up.

11.2 Safety

Any contractor performing vegetation clearing work on Unitil Companies property, shall have an active employee safety program conforming to the requirements of all applicable regulatory agencies. The equipment, training, and safety programs shall comply with the American National Standards Institute (ANSI) Z133.1 for Tree Trimming Activities and the requirements of OSHA CFR 1910.269 for Line Clearance Tree Trimming Operations. Unitil reserves the right to perform safety inspections.

The contractor will be required to comply with all Unitil Safety policies regarding vendor safety including all revisions made by FPL during the term of this contract.

11.3 Accidents, Serious Injuries and Supplier Caused Interruptions

Accidents, serious injuries, and contractor caused service interruptions, or accidents involving the public or contractor personnel must be reported immediately to the Unitil Company Representative. A complete and thorough investigation of such incidents shall be promptly conducted by the contractor or its liability insurance carrier. An Accident Investigation Report will be furnished to the Unitil Company Manager, Electric Systems.

11.4 Permits & Licenses

The contractor is responsible for obtaining all occupational permits and licenses legally required to do work. The cost of all such permits and licenses shall be paid by the contractor.

Construction, environmental, and tree removal permits are the responsibility of Unitil. The Company may require the contractor to obtain them. Such permit fees are directly chargeable to Unitil at cost.

It shall be the responsibility of the contractor to be knowledgeable and comply with appropriate city, county, state, and federal ordinances, agreements, laws, and regulations. This includes, but not limited to, laws pertaining to endangered species, wetlands, public trees, parks, and debris disposal.

11.5 Restoration Resources

The contractor shall provide crews for work performed outside of the normal workday due to Unitil initiated holdover or call-out of the tree crews for trouble restoration during weather events or otherwise. It is expected that the contractor Supervisor/General Foreperson shall dispatch, supervise, and communicate with Unitil's DOC or dispatch center to ensure the safe and timely restoration of service.

Unitil requires that the contractor's call out response capability be at least 60% at any given time based on the current number of crews currently on the Unitil system. The response time from initial contact to job site must be within one (1) hour of notification by Unitil to the local contractor Supervisor/General Foreperson. After arrival, contractor should assess work scope and mobilize resources to complete trimming required for restoration within 120 minutes of arrival. Unitil expects contractor to investigate missed SLA`s to identify opportunities for improvement. Unitil may establish performance incentives and liquidated damages based on contractors performance in achieving restoration SLA`s.

11.6 Public Relations

Unitil is committed to inform and educate our customers about our program goals while treating all customers, and their property, with respect. While performing work for Unitil, the contractor's line clearing personnel and equipment shall maintain a professional appearance. Line clearing personnel must be neatly dressed with shirts that clearly identify the contractor and in clothes appropriate for the work. Each crew should have at least one employee capable of communicating with the customers.
The contractor must respect and give consideration to the customer’s property, such as parked vehicles, sheds, outdoor furniture, lawns, livestock, and ornamental planting. Noise is to be kept to a minimum in the early morning. Gates shall be left as found.

11.7 Contractor Daily Timesheet Information

All contractors performing maintenance or construction trimming shall complete daily timesheets. See Appendix D for a sample copy of the timesheet.

The timesheet is designed to collect the necessary data that will be utilized to process contractor invoices and to calculate performance metrics. It shall be the responsibility of the Manager, Electric Systems or the designee to ensure the timesheets are completed daily, and that all required information is included.

Information on the daily timesheet includes:

General Information:

- Date
- Street
- Town
- Circuit
- Voltage

Pole Numbers:

- Company pole number
- Telephone pole number

Quantity of work:

- Number of sections trimmed
- Number of services trimmed

Type of work:

- Scheduled work
- Unscheduled work
- Construction related
- CWO number
- Storm work
- Other trouble
- Customer Trim Request

Type of Clearing:

- Trees trimmed – L (light), M (medium), H (heavy)
- Ground Cut
- Dead/Hazardous trees or limbs removed

Type of Construction:

- 1 – Single Phase, 2 – Two Phase, 3 – Three Phase
- Secondary Only
- Service Only

Time:

- Labor
- Equipment/Vehicle

Telephone Participation:

- Trimmed for Telephone Y/N
    - See individual IOP's for division of participation

11.8 Debris Disposal

Proper disposal of all wood residue from trimming and clearing operations is the responsibility of the contractor.

Contractor should not leave debris in residential or developed areas without customer permission and provided local ordinances allow. Alternative disposal methods are encouraged in undeveloped, rural areas or wherever practical. Blowing chips, mowing debris onsite, brushing up limbs below knee level for natural decomposition, and bundling for customer local debris disposal service are all options to be considered. The Contractor is responsible for cleanup of debris left behind that does not meet reasonable customer expectations. Unitil reserves the right to require contractor to clean up debris at their cost for excessive debris complaints or negligent disposal of debris.

It is the contractor's responsibility to oversee the cost-effective disposal of all wood residue generated from this operation. Increased travel time must be balanced with convenience of paying to dispose of wood residue. Contractor must balance between cost of tipping fees and travel costs to achieve best overall value to Unitil.

Appendix A – Sample Letter for Herbicide Applications

Unitil

Exeter & Hampton
Electric Company

Current Date

Town of Plaistow
Board of Selectman
145 Main Street
Plaistow, NH 03865

RE: Vegetation Control Program on Transmission Lines

Dear Selectman:

I am writing to inform you that Exeter & Hampton Electric Company will be conducting our vegetation control program on our transmission lines in parts of your town, scheduled to begin ______________. Please refer to the enclosed map of the area in which we will be working.

The general treatment method will be selective foliage treatment using Monsanto's Herbicide "Accord", and Dupont's "Krenite". The Accord and Krenite will be used for the full width of the right-of-way to control vegetation and if trees are too tall to be sprayed, they will be cut down and the stumps treated to prevent sucker growth.

All work will be done in compliance with applicable Federal and State of New Hampshire rules and regulations.

A Notification Request Coupon is enclosed for individuals who own property over which the right-of-way passes, or whose property abuts the right-of-way and who wish to be notified in writing thirty (30) days prior to any treatment. Coupons must be received no later than____________. Requests after this date will not be granted until the next treatment cycle. As we have done in the past, we will also notify all abutters along our transmission line by telephone.

Exeter & Hampton Electric Company will be working very closely with all parties involved and any questions or concerns you may have may be directed to me at the number below between 7:00 AM and 3:30 PM, Monday through Friday.

Very Truly Yours,

Safety & Facilities Coordinator

Business Office

114 Drinkwater Road
Kensington, NH 03833

..one: 603-777-5500
Fax: 603-777-5600

Email: ehec@unitil.com

Appendix B – Sample Notice for Herbicide Applications

Public Notice - Right-Of-Way Maintenance Schedule

To ensure safety and service reliability to its customers, Exeter & Hampton Electric Company will be conducting maintenance on a portion of its transmission rights-of-way from mid-August into September. Herbicides will be used to treat certain species of fast-growing trees while leaving undisturbed low-growing grasses and other vegetation. Accord and Krenite are approved by the U.S. Environmental Protection Agency and the N.H. Division of Pesticide Control, and will be applied by licensed professionals with hand-held application tools.

Right-of-Way Number	Approx. Treatment Commencement Date	Location
3358	August 18 - 22	Plaistow
3345, 3356	August 25 - 29	Plaistow, Kingston
3343, 3354	September 2 - 6	E. Kingston, Kingston, Kensington, Hampton Falls

Further information can be obtained Monday - Friday 8:00 a.m. - 3:30 p.m. by contacting:Daivid R. O'Brien, Supervisor
Unitil/Exeter & Hampton Electric
114 Drinkwater Road, Kensington NH 03833
603/772-5916 or 1-800-582-7276

A Notification Request Coupon is provided below for individuals who own property over which the right-of-way passes, or whose property abuts the right-of-way and who wish to be notified thirty days prior to any treatment. Coupons must be received no later than July 18, 1997. Requests received after this date will not be granted until the next treatment cycle.

Rights-of-way are gnerally located away from streets and may be identified by the metal tag on a pole or structure with a number on it. The Division of Pesticide Control has marked all known public water supplies along that rights-of-way and these areas will be avoided. It is the responsibility of each landowner or resident to make Exeter & Hampton Electric Company aware of the location of a potential water supply and any environmentally sensitive areas where herbicide application ought to be avoided.

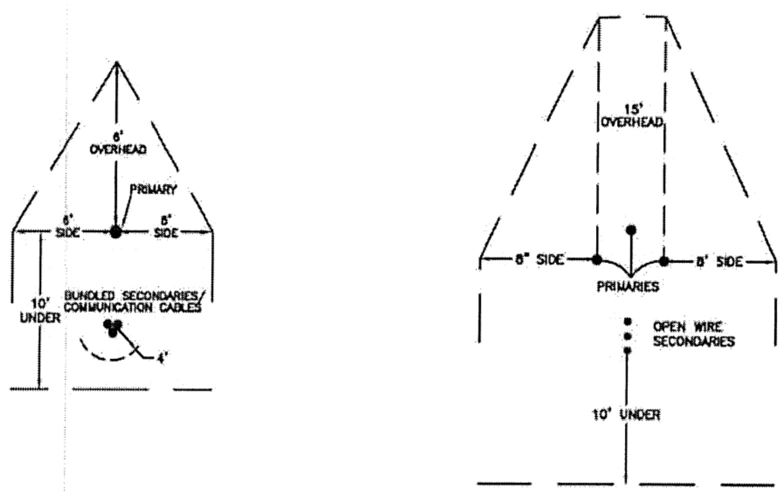
NOTIFICATION REQUEST COUPON

Name:__________ Town/City of InvolvedProperty: __________
Street Address:__________ Ph (Home) __________
Town: __________ Ph: (Work)__________
State:_____ Zip Code _____ Ok to use Work No: __Yes__No
Property of Concern: __________
Sensitive Areas: __________
Name of Utility Company: __________
Approximate Line and Pole Numbers: __________
For further information call (603) 772-5916 or (NH) 1-800-582-7276
Return by July 18, 1997

Unitil
Exeter & Hampton Electric Company

Appendix C – Distribution Clearance Standards Diagrams

MINIMUM CLEARANCE ZONE DIMENSIONS
FOR ELECTRICAL CONDUCTORS
AND COMMUNICATION CABLES



NOTES:

OVERHEAD CLEARANCE SHALL BE MEASURED VERTICALLY UPWARD FROM THE HIGHEST PRIMARY OR OPEN WIRE SECONDARY.

SIDE CLEARANCE SHALL BE MEASURED HORIZONTALLY OUTWARD FROM THE OUTERMOST PRIMARY OR OPEN WIRE SECONDARY.

UNDER CLEARANCE SHALL BE MEASURED VERTICALLY DOWNWARD FROM THE LOWEST PRIMARY OR OPEN WIRE SECONDARY.

NORMALLY REMOVE ALL BRANCHES WITH THE MINIMUM CLEARANCE ZONE BOUNDED BY THE DASHED LINE PERIMETER.

IF THE EXISTING CLEARANCE IS LESS THAN THE MINIMUM REQUIRED CLEARANCE BETWEEN THE TREE TRUNK OR LARGE HEALTHY LIMB (WITH STRONG CROTCH) AND WIRES, LEAVE THEM AND REMOVE ALL OTHER BRANCHES WITHIN THE MINIMUM CLEARANCE ZONE.

REV.	DESCRIPTION	BY	DATE	CHK	APR
A	UPDATED WITH BULLETIN REVISIONS	MP	02/05/09	NS	NS

REVISIONS

DRAWN:

CHECKED: SW

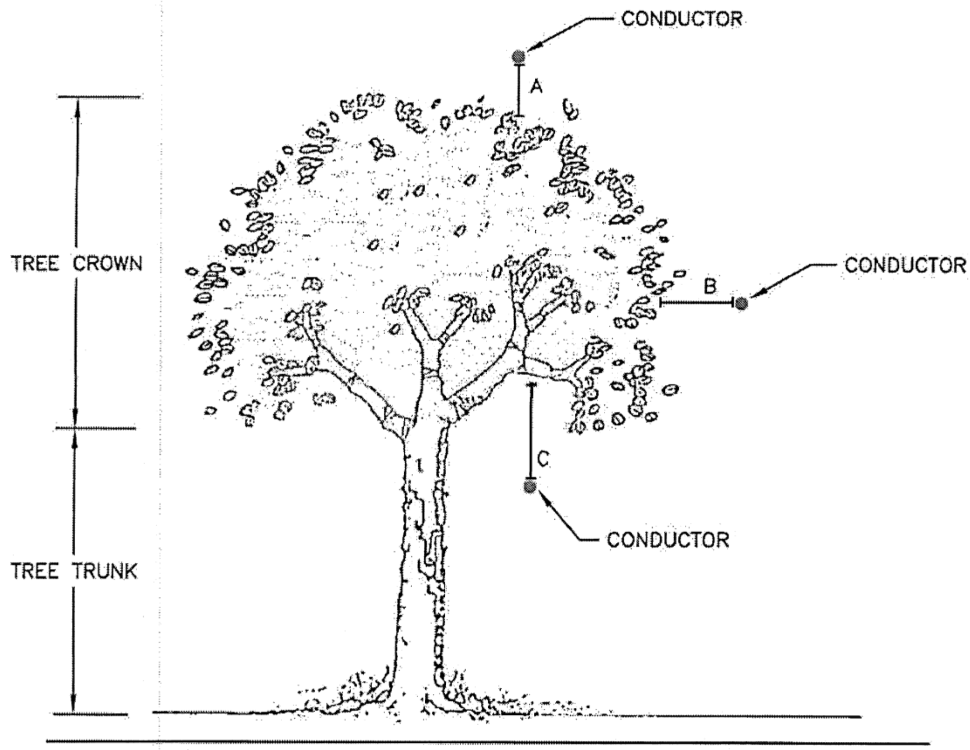
APPROVED: SW

Unitil
Unitil Service Corp.

Unitil Service Corp.

TREE TRIMMING CLEARANCES
FOR ELECTRICAL CONDUCTORS
AND COMMUNICATION CABLES

SCALE	DATE	SHEET	DRAWING NO.
N/A	11/30/00	1 OF 1	UAG0004



CLEARANCE	TYPE OF TRIMMING	SINGLE-PHASE MINIMUM CLEARANCE	MULTI-PHASE MINIMUM CLEARANCE	BUNDLED SECONDARY/ COMMUNICATION CABLE MINIMUM CLEARANCE
A	UNDER TRIMMING	10 FEET	10 FEET	4 FEET
B	SIDE TRIMMING	6 FEET	8 FEET	4 FEET
C	OVERHEAD TRIMMING (REMOVE OVERHANG SITUATIONS WHERE POSSIBLE)	6 FEET	15 FEET	4 FEET

REV.	DESCRIPTION	BY	DATE	CHK	APR
A	UPDATED WITH BULLETIN REVISIONS	MP	02/06/09	NS	NS

REVISIONS

DRAWN: MLC
CHECKED: SW
APPROVED: SW

Unitil Service Corp.

TREE TRIMMING CLEARANCES FOR ELECTRICAL CONDUCTORS AND COMMUNICATION CABLES

SCALE	DATE	SHEET	DRAWING NO.
N/A	11/30/00	1 OF 1	UAG0005

Appendix D – Contractor Daily Timesheet

Unitil

Vegetation Control Report

Year: ________

Week Ending: ____________

						Qty of Work		Type of Work						Type of Clearing			Construction			Time		Tel. Co.
Date	Street & Town	Circuit #	Voltage	Unitil Pole # From - To	Fair Point Pole #	# Sections Trimmed	# Services Trimmed	Scheduled Maintenance	Unscheduled Maintenance	CWO #	Storm Work	Clear / Open	Customer Trim Request	Trimming - Light, Medium, Heavy - (L,M,H)	Ground Cut	Dead/Hazardous/Tree Limb Removed	1 - 1 Phase 2 -2 Phase 3 - 3Phase	Secondary Only	Service Only	Labor	Equipment / Vehicle	Trimmed for Tel Co Y/N
	Totals:																					

Tree Contractor: Asplundh Tree Expert

Workers: ____________________

____

Equipment / Vehicle: ____________________

Tailboard Conference: Yes No

Foreman Initials:

Comments -

Unitil Rep. Signature____________________

Appendix E – Monthly Progress Report

Unitil System

Plan and Progress Reporting		
	Transmission	*Scheduled Work - Acres*
		Scheduled Work Complete - Acres
		Cumulative Schedule Accuracy
	Distribution	*4 kV Scheduled Work - Sections*
		4 kV Scheduled Work Complete - Sections
		13.8 kV Scheduled Work - Sections
		13.8 kV Scheduled Work Complete - Sections
		34.5 kV Scheduled Work - Sections
		34.5 kV Scheduled Work Complete - Sections
		Unscheduled Work - Sections
		Total Work - Sections
		Cumulative Schedule Accuracy
Effectiveness Metrics		
	Transmission	*Number of permanent outages*
		Number of momentary outages
	Distribution	*4 kV tree-related outages*
		4 kV pole miles
		4 kV cumulative tree outages per mile
		13.8 kV tree-related outages
		13.8 kV pole miles
		13.8 kV cumulative tree outages per mile
		34.5 kV tree-related outages
		34.5 kV pole miles
		34.5 kV cumulative tree outages per mile
Efficiency Metrics		
	Transmission	*Total Dollars Expended*
		Actual Work - Acres
		Cumulative Expense Per Acre
	Distribution	*Total Dollars Expended*
		Total Work - Sections
		Cumulative Expense Per Section

Appendix F – Transmission Clearance Standards

Transmission - Vegetation Management Clearance Standards

Right-of-Way in General - Clear cutting - Defined as the cutting of all vegetation in the right-of-way (edge to edge) at or near ground level.

Clear cutting or the removal of all vegetation at ground level, shall take place on all areas of the right-of-way except when prohibited in environmentally sensitive areas (such as wetland or exception areas) or in some land restricted areas. In these situations, Unitil shall apply the following minimum clearances to vegetation.

Unitil establishes the following minimum transmission clearance to vegetation in accordance with NERC Standard FAC 003-01.

Clearance 1 - The minimum clearance distances to be achieved **<u>at the time</u>** of transmission vegetation management work (when clear cutting is not an option) shall be based on the minimum approach distances as defined in Table 2 of ANSI Z133.1-2006.

Table 2. Minimum approach distances to energized conductors for persons other than qualified line-clearance arborists and qualified line-clearance arborist trainees.

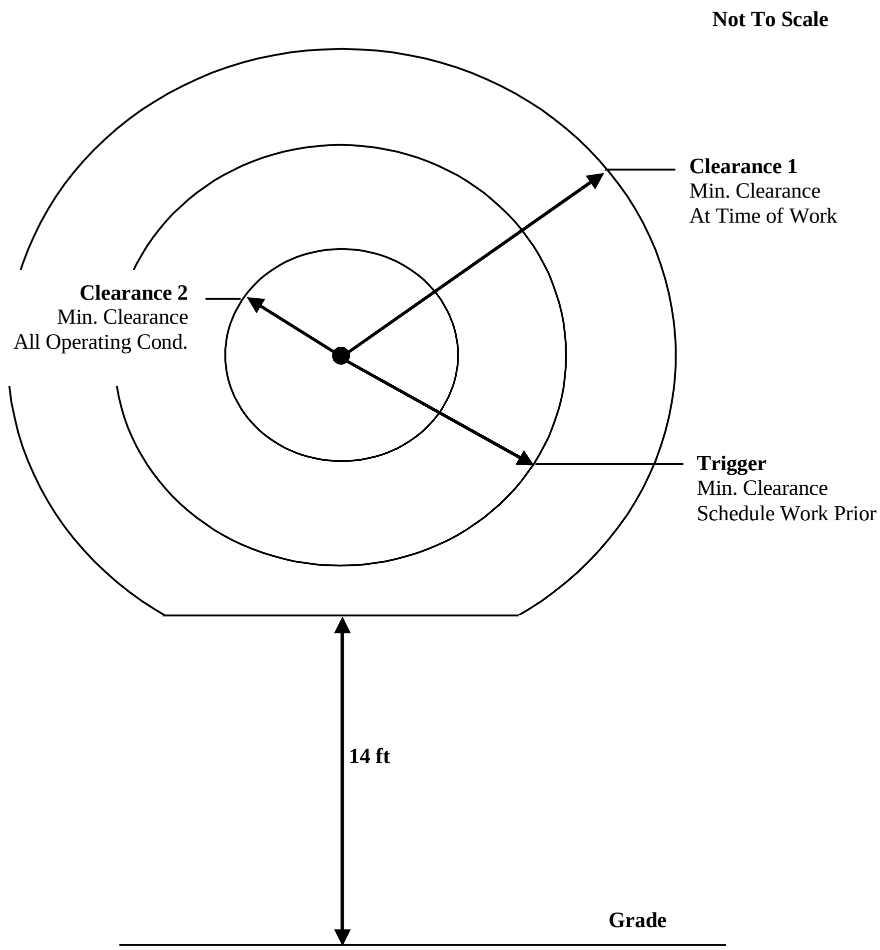
Nominal voltage in kilovolts (kV) phase-to-phase *	Distance	
	feet-inches	meters
0.0 to 1.0	10-00	3.05
1.1 to 15.0	10-00	3.05
15.1 to 36.0	10-00	3.05
36.1 to 50.0	10-00	3.05
50.1 to 72.5	10-09	3.28
72.6 to 121.0	12-04	3.76
138.0 to 145.0	13-02	4.00
161.0 to 169.0	14-00	4.24
230.0 to 242.0	16-05	4.97
345.0 to 362.0	20-05	6.17
500.0 to 550.0	26-08	8.05
785.0 to 800.0	35-00	10.55

* Exceeds phase to ground. Per 29 CFR 1910.333

ANSI Z133.1-2006: Table 2

Special Situations

In some special situations conductors may be constructed at the minimum conductor height allowed by the National Electrical Safety Code (ANSI C2-2007). In these situations the NESC allows the maximum height for human activity to be 14'. This may mean that ANSI Table 2 may not be met below the conductor. In this situation vegetation must not exceed 14' in height from the original design grade of the line.



In some design situations trees may need to be allowed to grow to their mature height that is greater than 14'. This could result due to environmental conditions; historical trees, fruit trees, or trees with a politically designated protected status. In these locations the line will be designed to be greater than **Clearance 1** at maximum load

These Special Situations should be recorded so that the appropriate prescriptions are applied to meet these design considerations.

Clearance 2 - The radial clearances to be maintained between vegetation and conductors under all rated electrical operating conditions. Unitil will maintain the distances specified in the Institute of Electrical and Electronics Engineers (IEEE) Standard 516-2003 (*Guide for Maintenance Methods on Energized Power Lines*) and as specified in its Section 4.2.2.3, Minimum Air Insulation Distances without Tools in the Air Gap. These distances are:

Table 5 IEEE Standard 516-2003 Section 4.2.2.3, Minimum Air Insulation Distances without Tools in the Air Gap	
Transmission system transient overvoltage factors are not known	
Voltage	MAID Distance
69 kV	2.45 feet
115 kV	2.45 feet
138 kV	2.94 feet
230 kV	5.14 feet
500 kV	14.68 feet

Clearance 2 is a radial distance shall always apply. In the special situations described above for clearance below the conductor **Clearance 2** will not be violated.

Where **Clearance 1** cannot be achieved Unitil shall establish a mitigation plan to ensure that **Clearance 2** is never violated by vegetation.

Trigger distances

To avoid violating **Clearance 2** or needing a clearance or line right of way to trim the trees the Unitil representative will schedule trimming before vegetation encroaches the radial distance listed in ANSI Z133.1-2006 Table 1.

Table 1 - Minimum approach distances from energized conductors for qualified line-clearance arborists and qualified line-clearance arborist trainees						
Nominal voltage kilovolts phase -to-	Includes 1910.269 elevation factor, sea level to 5000 ft*		Includes 1910.269 elevation factor, 5001-10,000 ft*		Includes 1910.269 elevation factor, 10,001-14,000 ft*	
	ft-in	m	ft-in	m	ft-in	m
0.05 - .03	***Aviod contact***		***Aviod contact***		***Aviod contact***	
0.301 - 0.75	1-01	033	1-03	0.37	1-04	0.40
0.751 - 15.0	2-04	0.70	2-07	0.80	2-09	0.85
15.1 - 36.0	2-11	0.90	3-05	1.03	3-03	1.00
36.1 - 46.0	3-04	1.01	3-09	1.15	3-07	1.09
46.1 - 72.5	4.02	1.26	4-09	1.44	4-03	1.30
72.6 - 121.0	4-05	1.35	5-01	1.55	5-06	1.68
138.0 - 145.0	5-02	1.58	5-11	1.80	6-05	1.96
161.0 - 169.0	5-11	1.80	6-11	2.05	7-04	2.23
230.0 - 242.0	7-10	2.38	8-11	2.72	9-08	2.95
345.0 - 362.0	13-01	3.99	15-00	4.56	16-02	4.94
500.0 - 550.0	19-00	5.78	21-08	6.60	23-06	7.16
765.0 - 800.0	27-04	8.31	31-02	9.49	33-09	10.29

* Exceeds phase-to-ground; elevation factor per 29 CFR 1910.269.
Note: At time of publication. The minimum approach distances in this table for voltages between 301 and 1,000 volts exceeded those specified by 29 CFR 19100269, in anticipation of OSHA adopting these distances during the life of ANSI Z133.1-2006.

ANSI Z133.1-2006: Table 1.

Slash-Debris

Unitil's easements should be free of debris and accessible to personnel, vehicles and machinery.

No disposal of debris by burial on the right-of-way will be permitted. In addition, burning under our existing facilities will not be allowed. All slash/debris generated from trimming/removing trees shall be removed from the right-of-way unless slash/debris can be handled in one or a combination of the following ways: Burning (permit must be obtained by contractor and no burning shall occur on the right-of-way), mulching slash/debris using mower, broadcasting chips so that there are no piles and no obstruction to ingress or egress of right-of-way.

Debris shall not be left in residential or developed areas without customer permission. This debris must be transferred to an approved disposal site.

All slash/debris shall be removed from the forested wetland (DEP) areas and disposed of away from wetlands area unless a DEP approved machine can do clearing and slash/debris handled in a approved method by the associated State. All work shall conform to Unitil's specifications and instructions.

APPENDIX 5.10

EFFECTS OF DEFERRED MAINTENANCE AND INADEQUATE CLEARANCE

UNITIL-NEW HAMPSHIRE

DEFERRED MAINTENANCE, INADEQUATE CLEARANCE, AND NORMAL PRUNING CYCLES

Deferred maintenance is a process in which tree growth is allowed beyond the limits prescribed by a regular maintenance cycle. This happens when the time between pruning is too long for the clearances obtained.

Inadequate clearance is the result of not pruning the branches far enough from the conductors to allow for the growth of the trees.

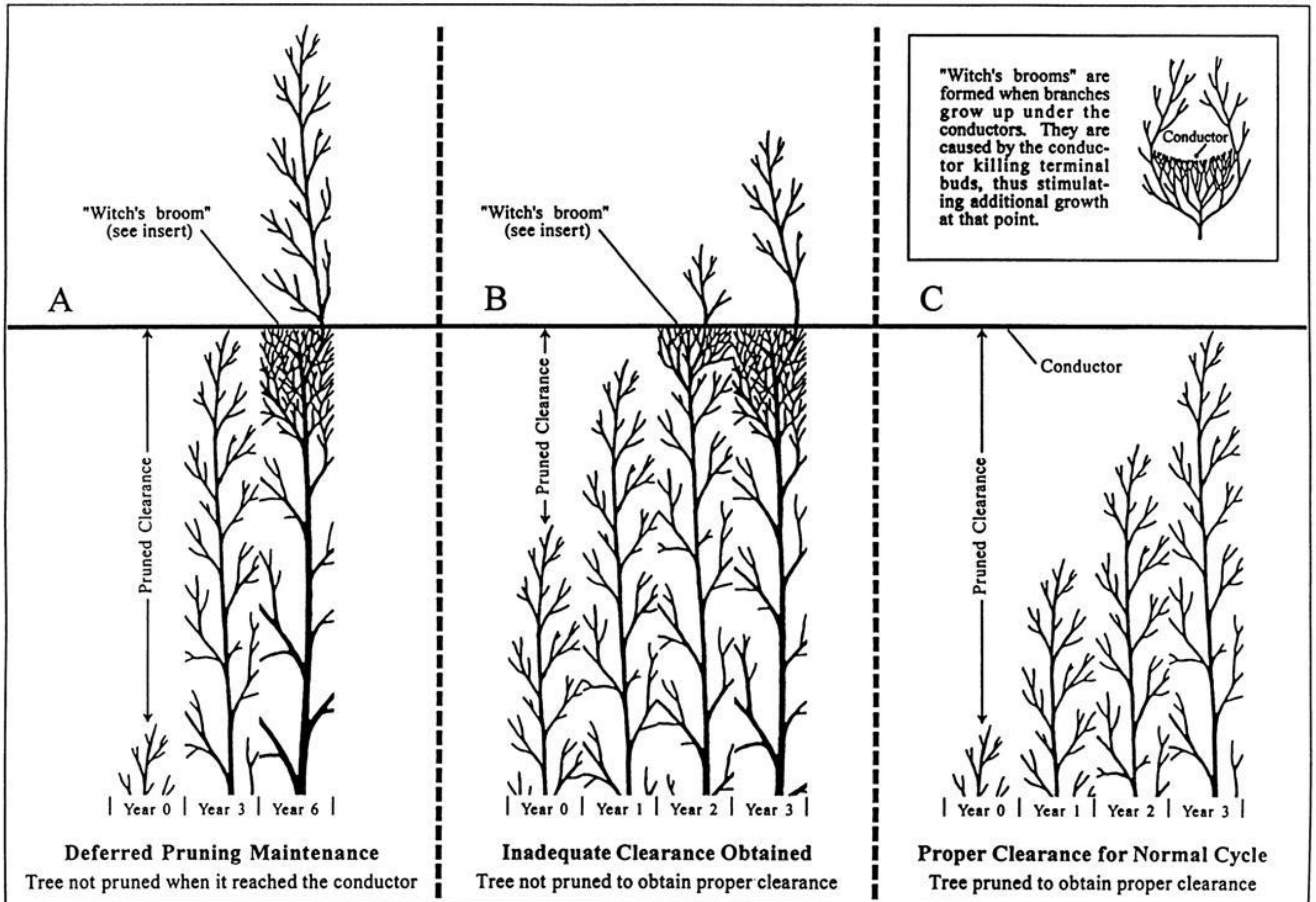
Deferred maintenance and inadequate clearance generally result in increases in the number of tree-related service outages and in the overall costs of the line clearance operations. Clearances and pruning cycles recommended in this report should be maintained to avoid these problems.

Figure A illustrates the typical results of three different top pruning situations for trees, based on a 3-year maintenance cycle. (Similar effects would occur for side pruning and other recommended cycle lengths.)

Situation 1: Sketch “A” illustrates the effect of deferred maintenance. The maintenance cycle should be such that when the tree limbs reach the conductor, the tree should be pruned. If maintenance is deferred, these limbs will grow around and between the conductors, producing a much more difficult and expensive pruning job. Branches will have to first be trimmed to the conductors to remove growth in close proximity to them. The branches will then have to be pruned again below the conductors to obtain proper clearance.

Situation 2: Trimming that does not provide adequate clearance around the conductors can produce the same situation created by deferred maintenance. Sketch “B” illustrates how inadequate clearance created a difficult and expensive pruning job, because branches grew around the conductors before the line was scheduled for the next pruning cycle. The clearances recommended in this report are the minimum necessary for the recommended cycles.

Situation 3: If normal pruning cycles are maintained (as shown in Sketch “C”) and proper pruning techniques and clearances are used, pruning costs will be reduced and stabilized over the long run. However, cost increases will occur if stability is lost due to budget cutbacks or reduction in clearance obtained.


A
"Witch's broom" (see insert)
Pruned Clearance
| Year 0 | Year 3 | Year 6 |
Deferred Pruning Maintenance
Tree not pruned when it reached the conductor
B
"Witch's broom" (see insert)
Pruned Clearance
| Year 0 | Year 1 | Year 2 | Year 3 |
Inadequate Clearance Obtained
Tree not pruned to obtain proper clearance
C
"Witch's brooms" are formed when branches grow up under the conductors. They are caused by the conductor killing terminal buds, thus stimulating additional growth at that point.
Conductor
Conductor
Pruned Clearance
| Year 0 | Year 1 | Year 2 | Year 3 |
Proper Clearance for Normal Cycle
Tree pruned to obtain proper clearance

APPENDIX 5.11

INTEGRATED VEGETATION MANAGEMENT – IVM

UNITIL-NEW HAMPSHIRE

Incompatible Target Brush Management

The electric utility vegetation management industry typically defines trees as species with woody stems greater than 4 inches diameter at breast height (4.5 feet above ground) that mature at heights greater than 20 feet. Immature tree stems (woody species less than 4 inches diameter at breast height and with the capability to exceed 20 feet in height are defined as incompatible target brush for the purposes of this manual.

It should be clearly understood that not all low-height vegetation on a right-of-way will eventually mature and pose a threat to overhead electric facilities. Small trees with low mature heights, shrubs, grasses, etc., are considered to be compatible with overhead electric facilities. It is neither cost effective nor beneficial to the environment to control this vegetation. Compatible, low-growing vegetation can also help to reduce the occurrence of tall-growing species, which helps to reduce vegetation management costs. Compatible vegetation should therefore be retained and encouraged as much as possible.

Immature trees (target brush) are a component of the vegetation workload that is sometimes overlooked because they typically do not pose an immediate threat to system reliability or safety. However, ignoring incompatible target brush and allowing it to mature can increase maintenance costs, impede or prevent accessibility to facilities, and can result in a significant increase to the tree workload as it matures. Incompatible target brush species can also threaten system reliability and safety as they mature and reach conductor heights.

Aggressive incompatible target brush species control is crucial in preventing future expansion of a utility’s vegetation workload and future cost increases. The methods used to control incompatible target brush also have an impact on cost effectiveness. Since target brush conditions, geography, terrain, and demographics all vary within a given utility’s service area, there are a variety of methods that should be implemented to control incompatible target brush species.

Integrated Vegetation Management

Integrated Vegetation Management (IVM) is a pest control concept borrowed from Integrated Pest Management (IPM) that considers biological, chemical, cultural, and physical (e.g., mechanical and manual techniques) methods to control undesirable vegetation. The method that is implemented to control undesirable vegetation at any given location is selected on the basis of treatment effectiveness, site characteristics, environmental impacts (including impacts to desirable, non-target vegetation species), safety, and economics. Flexibility is a key aspect of IVM.

Properly implemented, IVM is recognized as a methodology that encompasses a range of industry-established best practices. It is therefore an integral component of an effective vegetation management program.

IVM consist of six steps:

1. *Set Objective*. The focus for the objectives should be on environmentally sound, cost-effective control of species that potentially conflict with the electric facility while promoting compatible, early successional and sustainable plant communities.
2. *Evaluate the site.* Assess field conditions for planning purposes, establish or modify objectives, set budget and determine resources requirements.
3. *Define action thresholds.* The action threshold would include factors such as vegetation height and density targets that trigger specific control methods. These targets will vary from utility to utility and project to project.
4. *Select Control methods.* Objectives can be achieved through control methods such as manual, mechanical, herbicide or biological and cultural practices. The control method options are the focus of discussion in this paper.
5. *Implement IVM.* Vegetation management professionals implement minimum clearances distances.
6. *Monitor treatment and quality assurance.* There should be systems processes in place for documenting and verifying that vegetation management work is completed to specifications. These reviews can be comprehensive or based on a statistically representative sample.

In general, physical or chemical control methods are the most appropriate incompatible target brush control options for a given electric system. Biological controls (e.g., grazing by animals) and cultural controls (e.g., using fire to eliminate undesirable vegetation) have extremely limited application and are seldom used as a utility vegetation maintenance technique. However, the retention of low-growing, compatible vegetation on the wayleave (right-of-way) will inhibit the future growth of incompatible species and is therefore considered a form of biological control.

Incompatible Target Brush Species Management Technique Selection

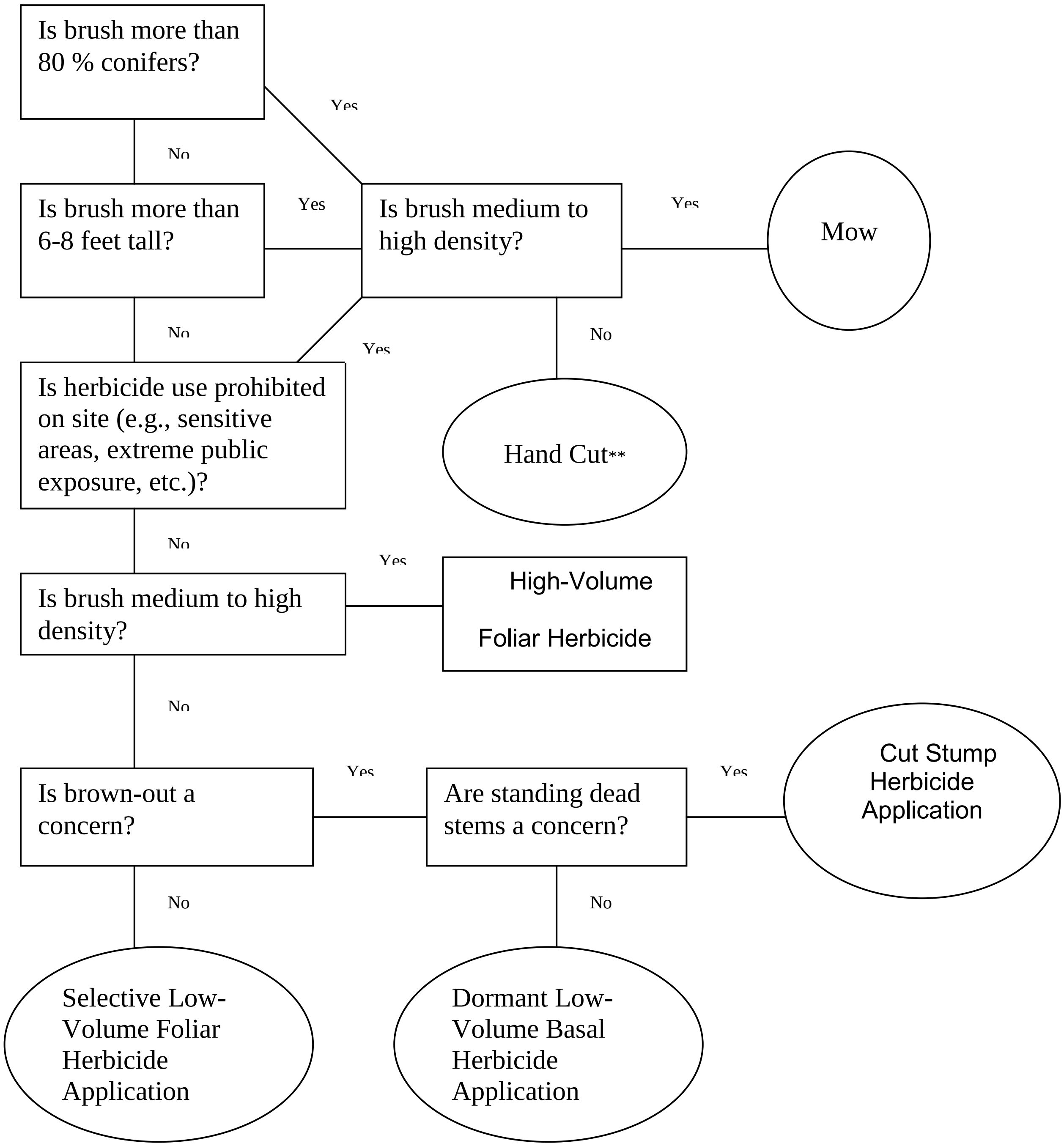
At any given site, the method selected to control incompatible target brush species has a direct impact on the vegetation communities that result following maintenance. In general, non-herbicide physical maintenance techniques (e.g., hand cutting and mowing) will encourage the proliferation of incompatible broadleaf brush species through stump sprouting, and in some species root suckering, thus creating a worse incompatible target brush problem than previously existed prior to the treatment. The use of herbicides will reduce stem densities of incompatible target species and provide long-term control of vegetation, thus reducing long-term maintenance expenditures.

The selection of an incompatible target brush species maintenance technique for a given area will be dictated by a number of factors. Target brush height and density will be the most important criteria in determining the appropriate control technique to employ. Additional factors that help determine an appropriate control method are terrain conditions, density of low-growing compatible vegetation, restrictions to maintenance practices (e.g., land use or public sensitivity), and the availability of expertise to successfully implement and monitor certain control methods such as specialized herbicide applications.

Figure 5.11.1 includes a matrix that will assist in developing initial incompatible target brush management prescriptions on the basis of general site conditions. The flowchart provides an indication of the complexities that are involved in selecting appropriate target species control methods.

The chart is not intended to replace the expertise and experience that should be provided by vegetation management professionals. Utilities should retain in-house staff with vegetation management expertise and/or consult with vegetation management contractors, consultants, and chemical company representatives before proceeding with implementing sophisticated IVM strategies to control vegetation.

FIGURE 5.11.1 DECISION FLOWCHART FOR PRESCRIBING BRUSH CONTROL TREATMENTS*



*This flowchart is a general guideline for prescribing an appropriate brush control treatment for a specific right-of-way site, but adequate training and experience are essential for successful implementation.

** If herbicide use is permitted on the site, cut stumps of deciduous trees could be treated with herbicides to control sprouting.

A professional approach and sufficient technical expertise is particularly critical when implementing a program that includes herbicide applications. A successful IVM program and general public acceptance of herbicide use will depend upon an electric utilities' commitment to a coordinated and professional effort to ensure the protection of both human health and the environment.

The following sections present techniques that are suitable for maintaining incompatible target brush species on electric systems.

Hand Cutting

Hand cutting uses a chain saw or brush saw to remove undesirable target vegetation. Hand cutting is the preferred maintenance technique for sites where obstacles (e.g., rocks, poles, or tower bases) exist or terrain conditions prevent access by mowing equipment and where herbicides cannot be used.

Hand cutting results in the immediate elimination of the above ground portion of undesirable target species. Compatible low-growing species are typically retained with this method, and a high level of selectivity can be achieved.

Unfortunately, hand cutting only affects the aboveground portion of the vegetation that is being maintained. The root collar area of the cut vegetation remains intact and viable, and hand cutting typically results in vigorous stump sprouting and, in some species, root suckering as well.

The rapid growth and multiple stems that typically follow hand cutting can increase incompatible target species stem densities significantly, resulting in a worse target species problem than previously existed. The control provided by hand cutting is short term, and the use of this technique alone should be limited. Long-term control of target species that have the capability of resprouting can only be achieved by applying a herbicide to the surface of the cut stump immediately following cutting (see Cut Stump Section).

When hand-cutting target vegetation, stems should be cut as close to the ground as possible and stump heights should typically not exceed 3 inches. Cuts should not be made on an angle, which results in pointed stumps that can be hazardous to humans, animals, and equipment.

Hand cutting can be performed at any site that is accessible to workers. This technique can be employed at any time of the year except when deep snow prevents cutting close to ground level.

Hand cutting should generally be limited to sites where target species stem densities are light to moderate and mowing is not economically feasible, and in areas where it is preferable to control incompatible target stems by cutting them at ground level.

Mowing

Mowing consists of mechanically cutting incompatible target species with a large cutting machine attached to a tracked or rubber-tired vehicle. Although there are numerous sizes and configurations of mowing equipment available, cutting heads for utility vegetation maintenance generally fall into two categories: rotary cutting heads and flail-type.

Rotary cutting heads consist of one or more blades that rotate horizontally, cutting and shredding vegetation. Flail-type mowers consist of metal teeth or chains attached to a rotating drum, which knocks down and shreds vegetation. Rotary style mowers are typically referred to as “brush hogs” and flail-type mowers are generally classified as “hydro-axes”.

Depending upon the size of the mowing equipment being used and the target species being managed, vegetation up to about 8 inches in diameter can reasonably be cut. Some specialty vegetation management equipment can even handle larger diameter vegetation.

As with hand cutting, mowing results in the immediate elimination of all undesirable target stems. However, since this technique is not selective, all desirable low-growing vegetation within the mower’s path is eliminated as well. Thus, the site is left in a disturbed and more open state, which allows tree seeds to germinate in addition to encouraging stump sprouting.

Mowing will not provide long-term control of communities of target species unless followed up with a herbicide application to control resprouting.

Mowing is the recommended maintenance technique for relatively flat areas with few obstacles (e.g., rock outcroppings, boulders, and stone walls) areas that support moderate to heavy densities of incompatible target species and in locations where herbicides cannot be used. As long as the site is accessible to mowing equipment, mowing will typically be more cost-effective and practical than hand cutting. This is particularly so when areas have been repeatedly mowed over several maintenance cycles and incompatible species densities have increased significantly.

Mowing can be done at any time of the year as long as sites are accessible. The only difficulties that may prevent mowing are steep slopes, debris on the wayleave or right-of-way, and rocky terrain. Mowing is also typically unacceptable on wet sites since heavy equipment can result in significant soil disruption and soft, wet soil conditions can impede or even prohibit the progress of machinery along the right-of-way.

Herbicide Treatments

The routine selective use of herbicides to control undesirable vegetation on electric utility systems is essential to reducing long-term costs and to maximizing the benefits of both tree and incompatible target brush species removal programs. Judicious herbicide use is an important component of an IVM strategy, and it is critical to the establishment of a low-growing plant community on the right-of-way that results in a cost-effective vegetation management program.

The effectiveness of selective herbicide applications has been well documented by the electric utility vegetation management industry. Selective herbicide applications control unwanted, tall growing target vegetation and encourages retention and expansion of desirable plant communities. Once these low-growing, desirable plant communities become well established, the occurrence of non-compatible tree stems decreases and future maintenance costs are reduced.

The establishment of communities of low-growing, compatible vegetation should be a primary goal of a utility target brush species control program. As progress is made towards achieving this goal, the inputs required to control undesirable vegetation can be reduced over time. The inputs required to manage vegetation can be described as herbicides (including adjuvants and carriers), labor, and equipment. Incentives to reduce the inputs are found in:

- Reducing environmental load
- Reducing costs.

There are two concepts to consider when practicing vegetation management through the selective use of herbicides on an electric utility system:

1. Selectivity for desirable vegetation based on herbicide selection - Herbicides are selected that predominantly control the undesirable target vegetation while leaving some compatible low-growing desirable vegetation (e.g., grasses) unaffected.

2. Selectivity for desirable vegetation based on application technique - Herbicides are directed vs. broadcast through specific application to the undesirable tall-growing target vegetation. Desirable low-growing vegetation does not receive treatment and is retained on the right-of-way.

In order to gain control of a right-of-way filled with undesirable vegetation, an initial clearing or “reclamation” treatment phase is typically required. Vegetation conditions are assessed and the appropriate herbicide and application technique is chosen. Generally, initial clearing is performed through the broadcast application of a herbicide on all heavy density, incompatible target brush species that typically exhibit various stages of height growth, depending on the time elapsed since the last mowing or hand cutting treatments were performed. In this phase, the vegetation in the target area is predominately undesirable, and a herbicide is applied to achieve coverage of all target stems within the entire right-of-way area to be managed.

Removal of incompatible target species through herbicide applications will promote a low growing plant cover of shrubs and herbs (grasses and forbs) that help to resist the establishment of tall growing, undesirable tree species. The conversion of a right-of-way to this state depends on the amount of desirable vegetation present at the time of the initial reclamation phase. Achievement of the minimum maintenance phase should require no more than two additional applications (4 to 7 years apart) and in some cases only one more treatment will be required. Each subsequent application in the ensuing and minimum maintenance phases uses less herbicide, labor, and fuel since less undesirable target vegetation is present. The reductions in the amount of chemicals used, in the labor required, and in the type and amount of equipment needed to maintain desirable vegetation on the right-of-way and control target species can translate into significant cost savings for a vegetation management program.

Herbicide applications in later phases are specifically targeted at the undesirable tree species by directed applications. Tremendous selectivity (both with herbicides used and application techniques employed) can be achieved once this phase is reached. Efforts in these later treatment cycles emphasizes minimum disturbance to the desirable, low-growing vegetation so as to promote and sustain its continued presence on the right-of-way.

Herbicide applications should be an integral part of a utility's IVM strategy. An important consideration is that herbicide use must be environmentally compatible and professionally supervised in order to achieve and maintain public acceptance. Crews that have received training in species identification, the handling of herbicides, and application methods should complete all herbicide applications. All applicable pesticide laws regulating herbicide use must be followed.

Crew personnel completing herbicide applications have significant responsibility to ensure that herbicides are handled and applied correctly. However, utility management personnel should have the ultimate responsibility for making sure that the overall vegetation management program, including the use of herbicides, is safe, professional, and effective.

The techniques used for herbicide application can be divided into two broad categories: directed (or selective) and broadcast. Directed, as implied, describes an application that is applied only to target stems. The amount of herbicide mix that is applied varies and is dependent on the density and height of target stems that are to be controlled. Broadcast applications are set at a fixed rate per area and once fixed, are independent of the density of the target stems that are to be controlled. Within these two application categories, specific application techniques can be defined as follows:

- Broadcast
- Foliar
- Cut Stubble
- Directed (selective)
- Foliar (High Volume and Low Volume Backpack Treatments)
- Basal Bark (Low Volume Treatment)
- Cut Surface (Stump Treatment)

Broadcast Foliar Application

Broadcast foliar applications are applied to the foliage of target tree species during the period of active growth when leaves are fully developed (late spring to early fall). A fixed herbicide rate per area is applied in a water solution and broadcast over the entire target area. Liquid volumes of mixture, which are predetermined, typically are in the area of 20 US gal/acre. Tall, high-density target tree species should generally be treated using higher volumes of solution to help ensure that the mixture penetrates all of the canopy layers. A common method for completing broadcast foliar herbicide applications uses a Radiarc® spray device (or similar boom equipment) that is mounted on a tractor or other vehicle suitable for traversing the right-of-way.

Broadcast foliar herbicide applications are sometimes the most cost effective way of initially controlling heavy density communities of tall-growing target tree species, particularly over large areas. Once an initial broadcast application has been made, stem densities of target vegetation will be reduced and subsequent maintenance should employ selective treatment methods.

Although broadcast foliar applications can be applied to target tree stems of any height, 15 feet is usually a good limiting height. However, more chemical will be needed to control taller target trees. Also, extremely tall target trees that die following treatment and remain standing on the right-of-way can be aesthetically unpleasing.

Since this technique will result the complete brownout of right-of-way vegetation, it is best suited for rural areas well away from the view of the general public. In general, broadcast foliar applications should be made to vegetation that is less than 6 to 8 feet in height.

Cut Stubble Applications

When a reclamation phase is necessary and the moderate to high density vegetation is too tall to initially implement a broadcast herbicide application, the site should first be mowed before herbicides are applied. A herbicide can be applied via a broadcast foliar application one or two growing seasons following mowing to vegetation that has resprouted. An alternative is to immediately follow mowing with a broadcast application of a soil-active herbicide, which prevents resprouting altogether. This technique, known as a cut stubble application, can be employed in more visually sensitive areas since treated vegetation has minimal leaf-out and brownout is substantially reduced.

This maintenance technique is subject to the same limitations described for mowing and broadcast foliar herbicide applications. The cut stubble technique is not selective, meaning that many desirable species are usually eliminated with this treatment method. Depending upon the herbicide formulation used, some selectivity for grasses can be achieved.

High Volume Foliar

High volume foliar is an application technique that typically utilizes a maneuverable vehicle (such as a truck or tractor) equipped with a large spray tank. Herbicide applications are applied to the foliage of target tree species using a hand held, high volume spray gun. Maximum effectiveness is generally achieved when target tree heights are between 2.5 and 8 and 15 feet.

The concentration of herbicide used for this technique is low and typically ranges from ½ to 1-1/2 percent of the spray solution. Volumes of spray mixture used will vary depending upon vegetation conditions, but will typically range from 100 to 400 US gallons of solution/acre.

High volume foliar applications apply herbicide to target species 8 to 15 feet tall and of medium to high density by thoroughly wetting all of the leaves and the stem. Operator skill is essential to achieving some selectivity with this technique. Spray pressure at the tip should be the minimum required to obtain plant coverage. The spray should be directed no higher than the target tree being treated. The use of a thickening agent or drift control additive is advisable to avoid the production of fine particles that may drift onto sensitive non-target plants. Nozzle tips that produce coarse droplets of solution should be used to help reduce drift.

High volume foliar applications should be performed during the period of active growth and when leaves are fully formed (generally from late spring to early fall). This technique can be performed on any site as long as terrain conditions permit access by spray vehicles.

When treating a right-of-way that has a high density of target species, the difference in results between selective high-volume foliar and uniform broadcast applications will oftentimes be minimal. The vast majority of plant materials on the right-of-way should be target species if either of these application techniques is utilized, which will result in a right-of-way with a browned-out appearance.

Low Volume Foliar

This method of application uses a higher concentration of herbicide (3 to 10%) than the high volume technique. The selectivity of the low volume foliar spray technique is achieved through the close application of coarse sprays that are directed at individual stems or clumps of non-compatible target species while directing the spray away from compatible vegetation.

Low volume applications are generally targeted at incompatible stems that are less than 6 to 8 feet in height and of low to moderate density. A conventional diaphragm or piston pump backpack is the most commonly used piece of equipment for low volume applications, but small volume battery operated tanks on ATVs have also been used effectively.

A spray wand can be used to deliver the herbicide solution. However, many applicators have found that equipment similar to the Dual Spray Gunjet® (DSG) offers more versatility. The DSG can be used with a conventional backpack or with the ATV. The DSG allows the applicator to switch between nozzles for the selection of a wide pattern for short spray distances or a narrow pattern for longer distances. Interchangeable nozzles increase the flexibility of this application technique.

Low volume foliar applications are directed at the top of the crown of target stems, and the upper 60 to 75% of the crown typically receives treatment. Application is made to wet the leaves, but not to the point of runoff. As with other foliar application techniques, low volume applications should be done during the period of active growth, when leaves are fully developed.

Low Volume Basal Bark

Low volume basal herbicide applications offer increased flexibility over foliar applications. Basal applications can be performed during the dormant season, as well as during the period of active growth. Dormant season applications allow crews to be productive during the off-season and can be advantageous in some locations where the brownout associated with foliar applications may be objectionable. This is a very selective application technique.

Basal applications control undesirable vegetation through the application of a herbicide and penetrating oil mixture to the lower 12 to 15 inches of target stems. The mixture typically contains a relatively high proportion of herbicide-to-oil (20% to 30% by volume) that effectively controls trees up to 6 inches in diameter at a low spray volume. The basal oil carrier can be kerosene, diesel oil, or a more refined substance such as mineral oil and other naturally derived oils. Many applicators tend to prefer a refined, low-odor oil carrier, which also has fewer environmental impacts than diesel oil or kerosene. There are ready-to-use formulations and blending services available that can eliminate the need for choosing oil carriers and mixing solutions prior to application.

Basal herbicides are typically applied with a backpack application unit equipped with oil tolerant seals. The backpack unit utilizes a low volume wand that can deliver a small amount of herbicide mixture to the lower stem of target species. Fixed pattern or adjustable nozzle tips are available to increase unit flexibility. The wand should have tip shut-off capabilities to avoid having the spray solution run out of the wand after spraying the stem. The entire circumference of the lower stem of target species is sprayed to wet, but not to the point of runoff. Basal applications can be made at any time of the year except when snow or water prevents spraying stems to the ground line, although they are most effective when applied in the late dormant season (from late winter to early spring) rather than in the late fall or early winter periods.

Cut Surface

Cut surface or cut stump applications involve hand cutting incompatible target vegetation followed immediately (at least within ½ hour) by a waterborne herbicide application to the exposed cambium layer along the perimeter of the stump surface. The treatment window can be extended by up to 6 months if the herbicide solution includes penetrating oil. If the latter method is employed, any exposed bark and root flares should be treated to the point of runoff to the root collar zone, in addition to treating the cambium layer. Indicator dyes can be included in the solution to help identify stumps that have already been treated.

Immediate cut surface applications are typically applied with a handheld trigger spray bottle. Due to the small amount of herbicide solution that is applied in very close proximity to the cambium area along the edge of the stump surface, there is minimal opportunity for non-target or off site contamination. Delayed applications may require a backpack applicator due to the greater volumes of herbicide solution that must be applied to each stump.

This is the preferred application technique in areas containing low to moderate densities of incompatible target stems where hand cutting is the preferred maintenance technique and herbicides can be used. Cut stump applications can be made year-round as long as snow does not prevent the cutting of stems at ground level. However, tardiness in the application or outright misses can drastically influence the effectiveness of the treatment. Treatments done in the early spring when tree sap flow is high can also have reduced effectiveness.

APPENDIX 5.12

GLOSSARY OF TERMS

UNITIL-NEW HAMPSHIRE

ANSI A 300 – The American national Standard for Tree Care Operations- Tree, Shrub, and Other Woody Plants maintenance – standard Practices (Pruning). American national arboricultural consensus standard.

Basal Application: The application of a herbicide and oil mixture to the lower or basal part of the stem.

Best management Practices: In the context of utility vegetation management, best management practices is the most effective, safe, economical and environmentally sound procedure (s) for maintaining electric rights-of-way

Brush: A woody plant less than 4 inches d.b.h. that may reach the conductor at maturity.

Callus: New growth made by the cambium layer around all wounds.

Cambium Layer: The actively growing tissue between the bark and sapwood of a tree that accounts for a tree's growth in diameter.

Certified Arborist: professionals dedicated to excellence in the field of arboriculture. Certified arborists are highly qualified in the care of trees and woody shrubs with knowledge of the most up to date, advance and proven age-old techniques. They have a number of years of experience, training and must pass rigorous testing before they can become a certified arborist. Term used here specifically in reference to utility arborists or those individuals with specific knowledge of utility arboriculture.

Clearance: The distance between vegetation and the conductors.

Climbable Trees: For the purposes of this report, trees with the trunk or a significant branch within 10 feet of the conductors that have sufficient limbs within 10 feet of the ground or other climbable object (shed, fence, etc.) so that they can be climbed without the use of climbing aids (ropes, spurs, etc.).

Compatible Vegetation: Vegetation that matures at a low height, so that it will never grow tall enough to interfere with the electrical conductors.

Conductor Security Zone: The area around electrical conductors into which vegetation should never be allowed to encroach. The size of this zone is determined primarily by the voltage of the conductors.

Coniferous: Any of the cone-bearing trees or shrubs, mostly evergreens. Coniferous trees usually do not sprout new growth when cut or trimmed.

Crew Foreman: Tree contractor's crew leader (man or woman) working with and supervising the line clearance crew.

Cut Stump Treatment: Removing vegetation by cutting, followed by herbicide application to the stump.

Cycle: See "Pruning Cycle."

Danger Tree: Any dead, dying, weak, diseased, or leaning tree (on or off the right-of-way) that could fall onto the conductors. (See "Hazardous Trees.")

Diameter at Breast Height (d.b.h.): Diameter of trees or brush measured at a point 4.5 feet above the ground.

Deciduous: Any perennial plant that sheds its leaves annually at the end of a growing season. Deciduous species generally sprout prolifically when cut or trimmed unless treated with a herbicide.

Drop-Crotching: See "Natural Pruning."

Evergreen: Any plant that retains its leaves year-round. These leaves are replaced gradually, thus retaining the "evergreen" appearance.

Foliar Application: The application of a herbicide to the stems, leaves, or needles of a target plant.

General Foreman: Supervisory personnel (man or woman) working for the contractor who has responsibility for work performed by that particular contractor's tree crews.

Ground-Line Cutting: Completely removing trees or brush at ground level.

Hazard Trees: Trees that are dead, diseased, infested by insects, deformed, shallow-rooted, or otherwise structurally unsound and that could fall into or cause other trees to fall into electrical conductors.

Healing: The roll or callus growth around a wound area. Trees do not actually heal, they simply "wall off" the damaged area and grow around, and eventually over, the wound.

Herbicide: A chemical used to control, suppress, or kill plants, or to severely interrupt their normal growth processes.

Hotspotting: Assigning line clearance crews in a manner that does not involve a systematic schedule.

Incompatible Vegetation: Vegetation that is undesirable or unsafe or that interferes with the intended use of the site.

Integrated Vegetation Management: (IVM) – A system of managing plant communities in which the managers set objectives; identify compatible and incompatible vegetation; consider action thresholds; and evaluate, select and implement the most appropriate control method or methods to achieve those objectives.

Line Clearance: Controlling vegetation to maintain proper clearance from conductors and to provide reliable electric service. This includes the pruning of trees to prevent limb contact, the control of brush to minimize future problems, and the removal of dead, diseased, weak, or interfering trees and branches that could fall onto the conductors. Synonymous with tree clearing, tree trimming, or vegetation management.

Minimum Clearance: The required minimum distance between tree and conductor to be achieved at the time of pruning to ensure that the tree will not grow into the conductor before the end of the maintenance cycle.

Natural Pruning: A method by which branches are cut to the branch collar at a suitable parent limb back toward the center of the tree. This method of pruning is sometimes called "drop-crotching" or "lateral trimming." Natural pruning is also directional pruning, since it tends to guide tree growth away from wires.

Non-Compatible Vegetation: See "Target Vegetation."

OFF-ROAD: not accessible to bucket/ lift truck.

ON-ROAD: accessible to bucket / lift truck.

Ornamentals: Trees used for landscaping or that otherwise have aesthetic value. Ornamentals are often hybrids, varieties, or grafted species.

Pollarding: Stubbing off major limbs until the tree assumes the desired size. The result is unsightly, and a multitude of fast-growing suckers will sprout from the stubs resulting in a line clearance problem more serious than before.

Preventative Maintenance:refers to planned or scheduled maintenance work as in cyclical trimming of electrical circuits.

Pruning: The removal in a scientific manner of dead, dying, diseased, interfering, objectionable, and/or weak branches of trees or shrubs.

Pruning Cycle: The period of time that elapses between the time a tree is pruned and then pruned again.

Qualified Vegetation Manager: A professional with the proper experience, education and training to successfully establish or supervise an integrated vegetation management program.

Reactive Maintenance: Non-scheduled work including restoration, customer trim requests, and operations hot spot requests.

Reliability Enhancement Program: (REP) refers to a planned program aimed at improving reliability on a given circuit or portion of circuit. Through analysis of reliability data, investigation of types of interruptions, a planned approach is developed to resolve the reliability issue through a combination of vegetation maintenance, construction changes or both.

Removal: Completely removing an entire tree to ground level; required when a tree is described as a danger tree or when a tree should be removed for other reasons. Also, any tree that is a candidate for removal.

Residential: See "Urban."

Rounding Over: The making of many small cuts so that the tree top is sheared in a uniform line. This creates an unhealthy tree condition and results in rapid regrowth directly back toward the electrical conductors.

ROW: refers to utility rights-of-way

Rural: An area that is not directly associated with a permanent or seasonal residence where vegetation is not intensively managed for aesthetic values. This includes areas of agricultural and forest land use, as well as undeveloped sites within otherwise urban or residential neighborhoods. Rural areas are commonly dominated by native species of trees, shrubs, and herbaceous vegetation.

Selective Herbicide: A herbicide that, when applied to a mixed population of plants, will control specific species without injury to others.

Shearing: See "Rounding Over."

Shrub: A woody plant normally maturing at less than 20 feet in height, presenting a generally bushy appearance because of its several erect, spreading, or prostrate stems.

Side Trim Stubbing: Stubbing off portions of limbs along the side of the tree to obtain clearance. The result is not only unsightly, but on many species a multitude of fast-growing suckers will sprout from the stubs, soon resulting in a line clearance problem more serious than before. The stubs are quite likely to fall victim to decay or disease.

Side Pruning: Cutting back or removing side branches that are threatening the conductors; required where trees are growing adjacent to conductors.

Slash: Debris resulting from a tree clearing operation.

Species: The basic category of biological classification, intended to designate a distinct group or kind of plant or animal having common attributes.

Specifications: All the terms and stipulations contained in a contract pertaining to the method and manner of performing the work or to the quantities and qualities of the material to be furnished under the contract, including amendments, revisions, deductions, or additions.

Sprout: New growth originating from adventitious buds, usually induced by removing a limb.

Target Vegetation: Woody species capable of growing tall enough to interfere with the electrical conductors and/or access to the electrical conduction system.

Top Pruning: Cutting back large portions of the upper crown of a tree; required when trees are located directly beneath a conductor. Sometimes called topping.

Translocated Herbicide: A herbicide that is moved from its point of entry throughout a plant via the vascular system.

Translocation: The transfer of substances from one location to another in the plant body.

Tree: A woody plant normally maturing at 20 feet or more in height, usually with a single trunk, un-branched for several feet above ground with a definite crown. Any trunk that is over 4 inches d.b.h. can be considered a tree.

Tree Crown: Upper portion of the tree; the branches or leaf area.

Trimming: Cutting back tree branches or shrubs, not necessarily in a scientific manner, to shape or reduce the size of the tree or shrub.

Trimming Cycle: See "Pruning Cycle."

Troublesome Species: Trees that exhibit great potential to grow into contact with electrical conductors due to their growth patterns.

Under Pruning: Removing limbs beneath the tree crown to allow wires to pass below the tree.

Urban: An area in direct association with permanent or seasonal residences, commercial properties, or other developed areas, where the existing vegetation is intensively managed for aesthetic value. This includes all landscaped areas, such as business and industrial properties, golf courses, lawns, and parks. Urban areas are typically stocked with yard or street trees of high aesthetic or ornamental value.

Volunteer Trees: Trees that are established naturally, rather than being planted.

Windthrow: The uprooting of trees due to wind.

Whorl: A circle of three or more similar parts around a central point, as three or more leaves growing around a twig at one spot or node. The circular arrangement of branches about the trunk of conifers.