

# **Limb Re-Growth Survey**

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## **INTRODUCTION**

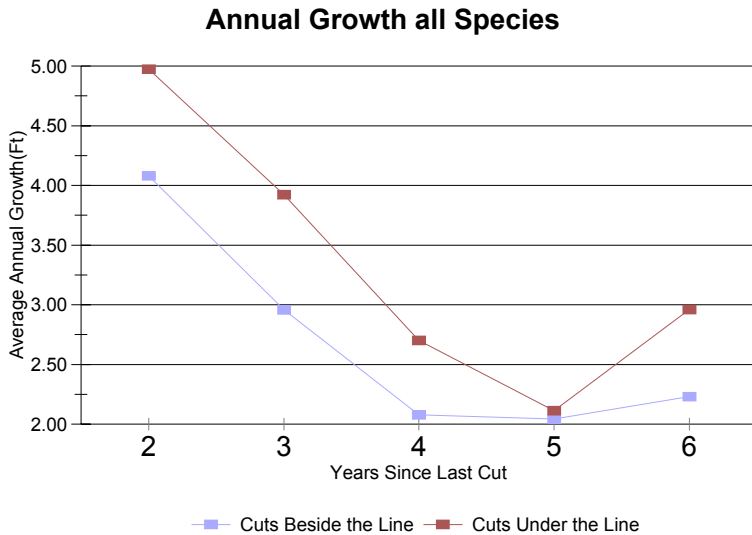
During the last several months of 2003 and early 2004, DEMCO personnel conducted a survey of the entire DEMCO service territory for the purpose of determining the rate of re-growth of limbs which were trimmed previously in the vicinity of power lines. The survey, though not totally random, was conducted in such a way as to obtain data from as many tree species, soil conditions, hydrology, and growth conditions as possible. The data were taken on pre-prepared forms so that all pertinent data would be correctly obtained. Data on the tree species, location of tree, size, quality of cut, and whether the cut was below or beside the line, along with other data were recorded along with the growth of the limb from the original cut to the limb tip. The samples were removed and measured. By knowing the location of the sample, the year in which the tree was last trimmed was determined. Counts of growth rings on the limbs or counts of bud-scale scars were made to confirm the years of growth. A total of 153 samples were evaluated ranging from one year to six years of re-growth.

## **FINDINGS**

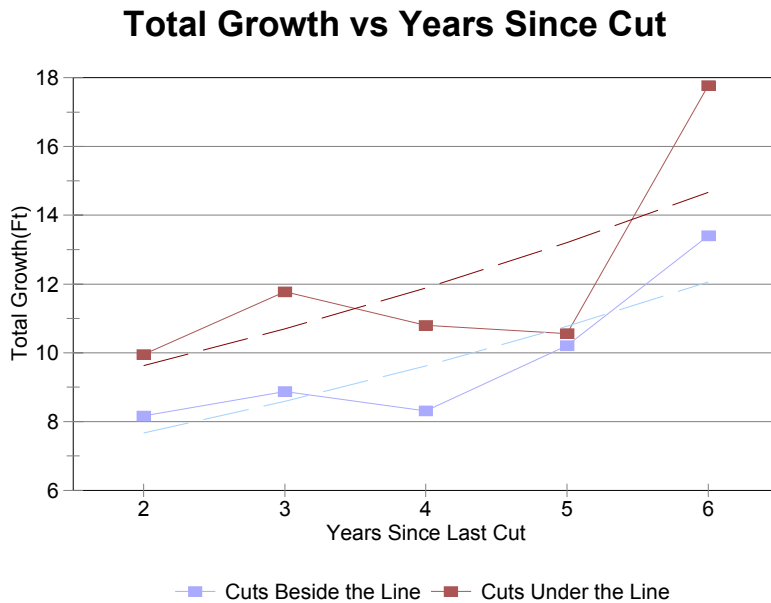
The data for each sample were entered into a computer program and sorted in various manners. Average growth rates were determined by species and evaluations were made to determine the affect of the extent of trimming and the quality of the cuts had on growth. Other factors such as average area rainfall were also included in this study. Attached are several graphs, charts, and tabulations that summarize the findings. Statistical studies, including multi-value regression analysis, were performed on the data to derive these facts. Some general facts derived from these studies are tabulated below.

1. Improper cuts increased the growth on average ½ ft. per year.
2. Heavy trimming results in one foot more growth per year compared to medium.
3. Light trimming results in one foot less growth per year compared to medium.
4. Limbs re-grow about ½ ft. less per year (in a two to five year period).
5. The limbs on larger (older) trees grow about ½ in. per year less per inch of DBH (diameter breast high).
6. Limb re-growth is significantly influenced by the amount of rainfall.
7. Limbs cut below the line grew at a rate (vertical growth) of one ft. per year faster than limbs trimmed beside the line (horizontal growth).

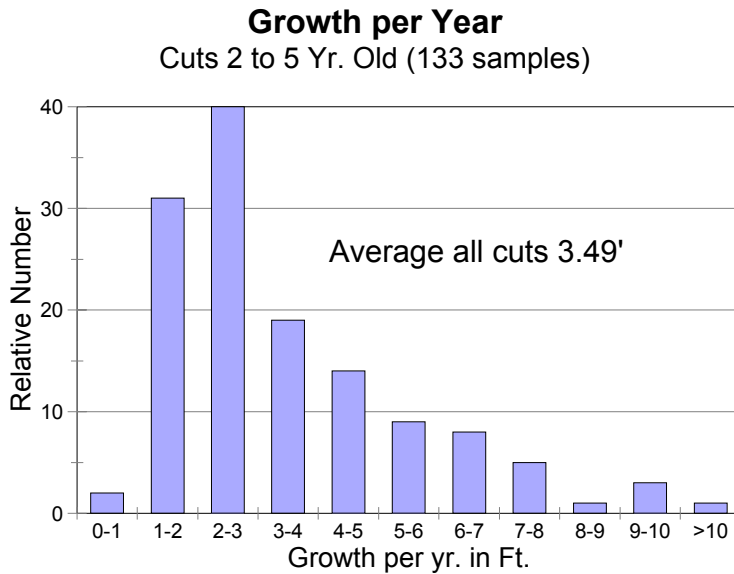
The graph below shows the relationship between average annual growth and years since last cut for cuts made immediately below the line and beside the line. It clearly shows the fast growth early and the difference between the rate of vertical and horizontal growth of the limbs. The increase in year six is likely due to rainfall and the mixture of tree species in the one circuit sampled with six years of growth.



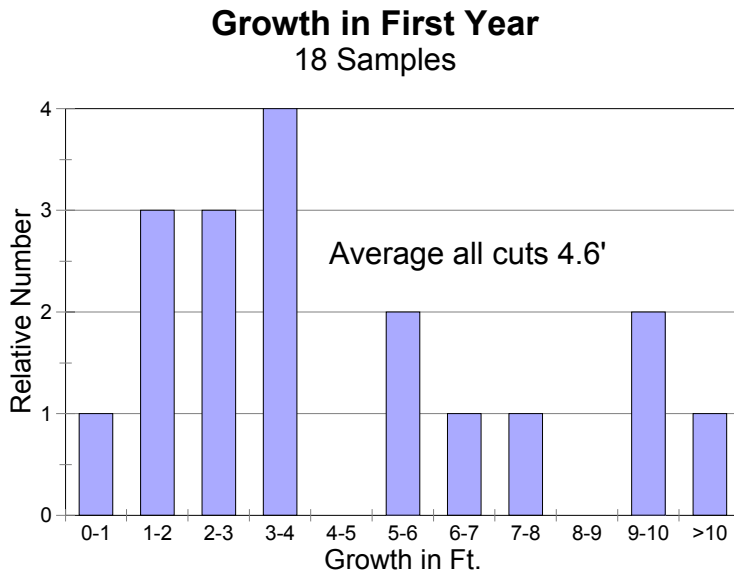
The graph below depicts the total growth in the two to six year growth cycles and with dashed lines indicating the best fit of a straight line to these data points.



The average growth per year for all types of cuts and locations was approximately 3.5 ft. per year for samples cut within two to five years (see graph below). The majority of the samples grew between one and four feet per year however; many samples grew quite a lot more.

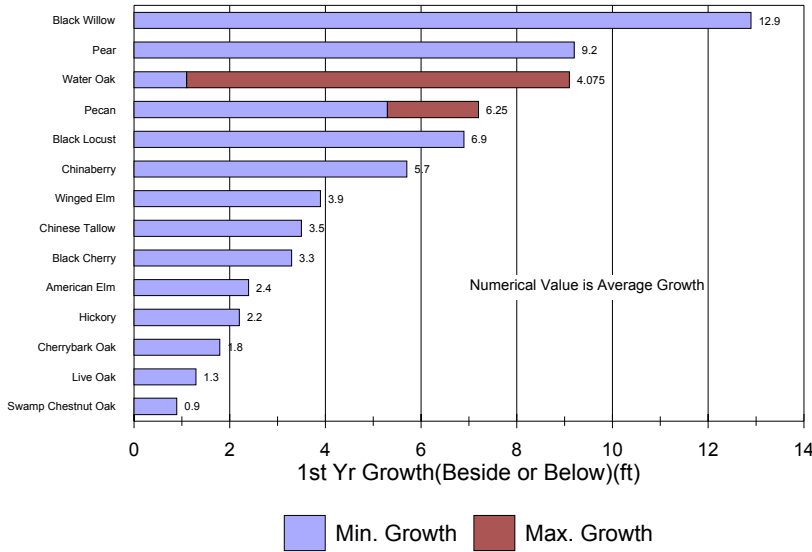


The average growth in the first year after trimming was over 4.5 ft. (see graph of Growth in First Year).

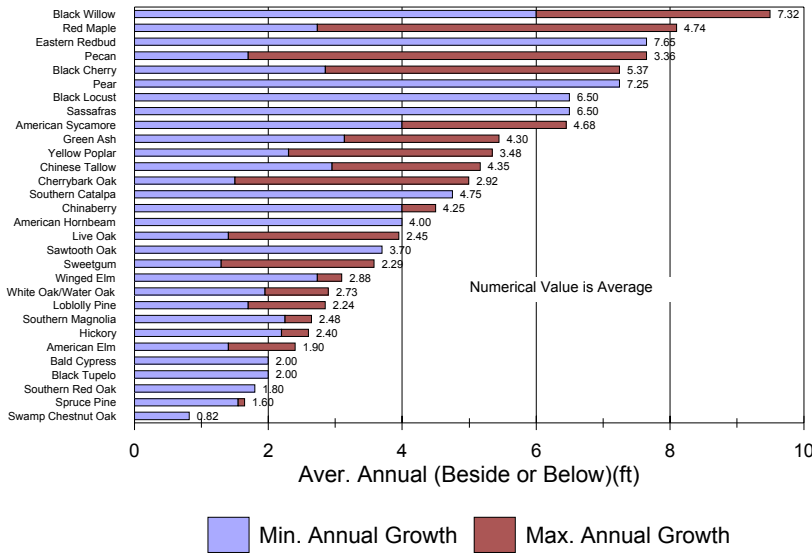


The variation by species in average annual growth is quite large. In the survey the one-year limb re-growth varied from a high of 12.9 ft. to a low of 0.82 ft. The graphs that follow depict the growth by species for the first year and average annual growth for the two to five yrs. growth cycle.

### Growth By Species First Year Growth



### Growth By Species Aver./yr. for 2 to 5 yrs. of Growth



From the data collected we divided the species sampled into three broad groups based on average growth of trimmed limbs. We identified the species that grew more than five feet per year as fast growth, those that grew three to five feet as moderate growth and those that grew less than three feet as slow growth. Below is a list of species by growth type.

**Fast Growth (average growth per year of more than 5 ft.)**

1. Black Willow
2. Red Maple
3. Eastern Redbud
4. Pecan
5. Black Cherry
6. Sassafras
7. American Sycamore
8. Green Ash
9. Yellow Poplar
10. Chinese Tallow
11. Sugarberry

**Moderate Growth (3 to 5 ft. per year)**

1. Cherrybark Oak
2. Southern Catalpa
3. Chinaberry
4. American Hornbeam
5. Live Oak (Young)
6. Sawtooth Oak
7. Sweetgum
8. Winged Elm

**Slow Growth (less than 3 ft. per year)**

1. White Oak/ Water Oak
2. Loblolly Pine
3. Southern Magnolia
4. Hickory
5. Live Oak (Mature)
6. American Elm
7. Bald Cypress
8. Black Tupelo
9. Southern Red Oak
10. Spruce Pine
11. Swamp Chestnut Oak

Below are some example photos of some extraordinary limb samples.



Photo 1. Black Willow 19 Ft., 2 years.



Photo 2. Cherry Bark Oak 10.3 Ft., 4 years.

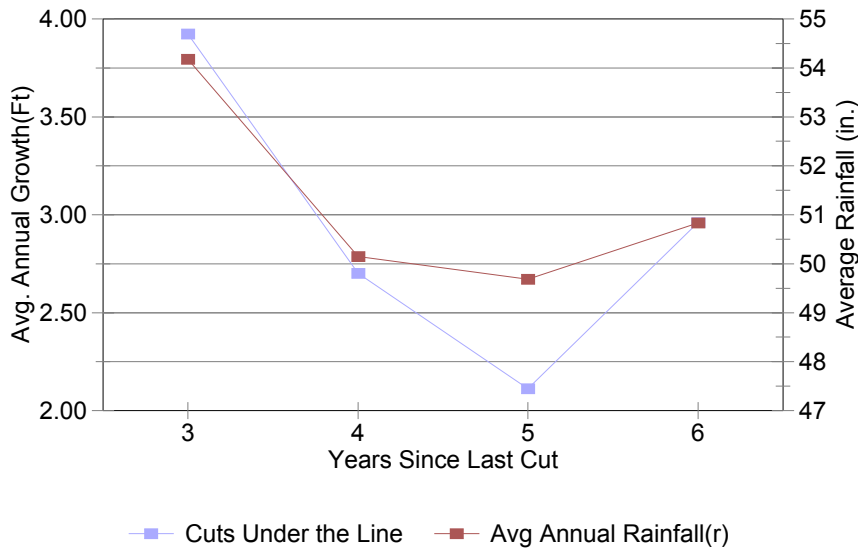


Photo 3. Black Locust 13.9 Ft., 2 years.

Rainfall data for the six years covered by this survey were recorded as reported by the National Weather Service for Baton Rouge, LA. The average was 53.3 inches for these six years. The normal average for this area as reported by the NWS is 63.08 inches. The correlation between limb re-growth and total rainfall is very high (See graph below). From the fact that the average over the study period is nearly 20% below normal, one would expect growth in a normal year to be even higher than the results of this study would suggest. Multi-value regression analysis suggest for the two to five year growth intervals studied that a growth of an additional 0.05 ft. per inch of rainfall should be expected. Using the rainfall average during the study and the normal rainfall average we would expect additional growth in normal years of approximately 0.5 ft. for all average annual growth rates.

<b>Year</b>	<b>Rainfall</b>
1998	56.59
1999	47.82
2000	38.05
2001	62.34
2002	56.98
2003	43.22
Normal	<b>63.08</b>

## Growth and Rainfall



Other factors affecting growth which were not studied are soil types, location relative to other trees, location relative to ditches and bodies of water, fertilization (either natural or applied), type of cut (drop crotching, etc), relative position of original cut to top of tree, and relative angle of growth and line. Further studies evaluating these factors should be considered in any future survey.

### NESC IMPLICATIONS

There are a number of reasons why these data are important. First is to establish a relationship between cleared right-of-way widths and re-trim cycles. If you expect limbs to grow 2.5 ft. per year and your rights-of-way limits are ten feet from the energized conductors, then you might believe that re-trimming will only be necessary before four years to keep the limbs from touching the lines. But this is not enough to meet all clearance requirements. The National Electrical Safety Code Section 218 Tree Trimming states

#### A. General

1. Trees that may interfere with ungrounded supply conductors should be trimmed or removed. NOTE: Normal tree growth, the combined movement of trees and conductors under adverse weather conditions, voltage, and sagging of conductors at elevated temperatures are among the factors to be considered in determining the extent of trimming required.
2. Where trimming 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.

B. 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.

It is clear from this Section that the NESC expects that electric utilities will consider not only the normal tree growth when designing and maintaining overhead power lines but others factors as well. Below are sample calculations for a typical 14.4/24.9 kV line following the requirements of NESC Section 218. These calculations are broken out into the factors that Section 218.A.1. requires the designer and owner to consider.

**Assumptions:**

1. Five year re-trim cycle
2. Voltage phase-to-ground 14.4 kV
3. Line construction RUS VC-1
4. High wind conditions (winds over 100 mph)
5. Tree movement 10% of height of tree
6. Conductor sag at design temp. 6 ft.

**Normal Tree Growth**

The average growth per year for a five-year cycle is 2 ft. beside the line. This was for a period when the average rainfall was only 47.8 inches so adjusting for normal rainfall of 63.1 inches we would have an average growth of 2.6 ft. per yr. or 13 ft. for the five years (this is for average growth only and does not reflect the higher growth rates for some tree species).

**Tree Movement**

Assuming the conductor is at 34 ft. the 10% sway expectation under high winds requires an additional 3.4 ft. of clearance.

**Conductor Movement**

With a high wind condition the conductor would be expected to displace from its normal position with a distance equal to the sag at mid span, in this example, 6 ft.

**Voltage**

To provide safety for the public and workers, the required horizontal clearance from 14.4 kV lines when wind displacement is considered is 4.5 ft.

Therefore the trim-back distance under high wind conditions would be the sum of the above or 26.9 ft. from the conductor to the cut for average tree growth assuming the tree sway and the conductor swing brings the conductor and tree together. An additional 3.5 ft, would be added for the three-phase construction of the assumptions since the conductor is attached approximately 3.5 ft. from the center of the pole. This brings the total to over 30 ft.

Very few utilities routinely cut back 30 ft. on either side of 14.4/24.9 kV lines. This may be because of the assumptions we have made. We have in this analysis added the movement of the conductor and the limb assuming that they move in opposite directions (bring them closer together). In a storm, this is possible if the conductor begins to swing but not likely in any but the very severe storms as assumed in this example. We have also assumed that the voltage clearance is the full safety clearance required by the NESC for protection of personnel and the public. Assuming only the conductor moves and the goal is to prevent the limb from contacting the line (since people are not likely to be in a tree during a severe storm) then we have a clearance requirement of only 19 ft. for storm conditions.

For normal weather clearance requirements, we would assume less conductor displacement (maybe one third of the sag). This depends on the type of conductor and the tension to which it is strung but for normal lines in south Louisiana this is a safe assumption. We could also assume moderate limb movement in the same direction as the conductor (again maybe one third of that in the above assumptions). We therefore would have a clearance requirement of 13 ft. for limb growth plus 2 ft. for conductor sag minus 1.1 ft. tree sway (minus since the tree and conductor are assumed to move in the same direction) plus 4.5 ft. voltage clearance plus 3.5 ft. for three phase or 21.9 ft. and 18.4 ft. for single-phase lines. Therefore, for a minimum we should use nothing less than the greater of these two options or 21.9 ft. for three-phase and 18.4 ft. for single-phase structures measured from the center of the pole line for normal construction. For new line clearing, more trees may have to be removed so as to have only light trimming on the trees to remain. The light trimming promotes less re-growth and less costly right-of-way maintenance over time.

Clearance calculations for below the line would include most of the above requirements, namely 1) Tree growth, 2) Sag, 3) Voltage, plus 4) the attachment height of the conductors. In the example above we have tree growth at 3.6 ft. (one foot additional growth for trimming beneath the line) per year or 18 ft. plus 6 ft. for sag and 3.25 ft. (40 inches) for voltage clearance. This is a total clearance of 27.25 ft. below the attachment height of the conductors that in this example is 34 ft. The sag used should be the maximum sag anticipated at either high conductor operating temperatures or sag due to the extra weight of ice during an ice storm, whichever is greatest. This says we should **cut to within 6.75 ft. of the ground** (2.25 ft. for lines built on 35 ft. poles). Why not cut it to the ground and keep it under control?



Photo 4. Bad trimming of a fencerow under a line



Photo 5. Good trimming under a single-phase line with three herbicide cycles



Photo 6. 69 kV right-of-way after three herbicide cycles



Photo 7. One-Year Re-Growth Due to Re-Trimming Under a Three-Phase Line

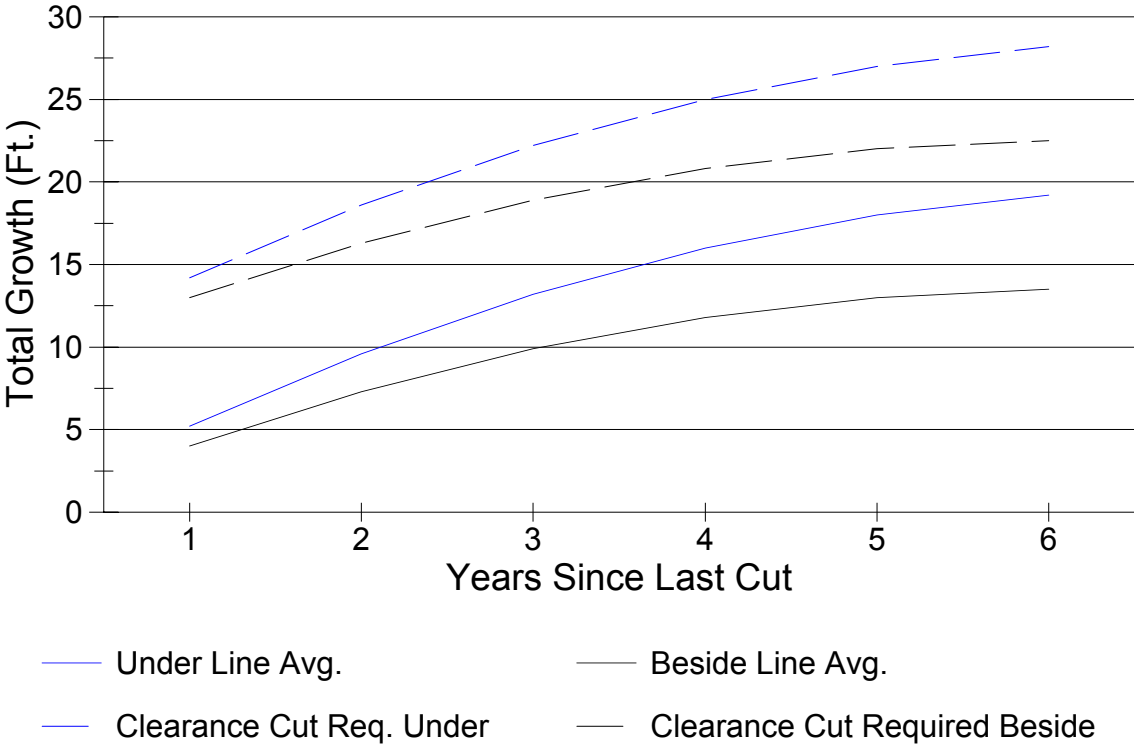


Photo 8. Good Tree Trimming Under a Line

Below is a graph of total limb re-growth using data from this study that has been adjusted for normal rainfall and smoothed to remove large year-to-year variations due to the size of the sample. It assumes normal cutting and proper cuts. It more clearly shows the rapid early growth and the difference in growth for cuts below the line and beside the line. This graph can be used to better evaluate the affect of cutback distance and various re-trim cycles. These curves are for the average growth only and do not represent extreme growth species. The dashed lines include the limb growth and the clearances calculated in the above sample calculation above for the normal weather cases and are for the clearance from the energized conductors on one side and do not include the distance from the pole to the conductor for multi-phase lines constructed on crossarms.

# Total Limb Re-Growth

## Adjusted to Normal Year



**CONCLUSIONS**

Several conclusions derived from this study are that for a five-year re-trim cycle, cut back distances, on average, should be no less than 18.4 ft. from the energized conductors to provide for the NESC required clearances in normal weather. Trees should be removed below the lines since growth of more than 18 ft. could be expected and clearance of over 27 ft. is required when code clearances are considered. If trees are trimmed and not removed under a line, then a five-year re-trim cycle is the maximum one could expect to provide adequate clearance. All cuts should be made in a proper manner and re-trimming should be done at a frequency to prevent the need for heavy trimming. For new construction, additional clearance or tree removal should be considered if heavy cutting would otherwise be required. Rainfall should be monitored to determine if more frequent inspections of lines should be undertaken to look for limb conflicts with lines prior to normal re-trimming.