Live Trees Affect Antenna Performance

Living wood resembles human tissue more closely than it does lumber, and can increase the losses of nearby antennas by several decibels.

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— QST February 2018
From *The Doctor is In, QST* June 2017:

**Q** William, VE2WMA, asks: My dual-band, single-trap, ground-plane antenna for 40 and 20 meters is encircled by towering pine trees, a few of which are as close as 3 feet away from the vertical radiating element and extending to about 10 feet away. How does this impact antenna effectiveness? How far away should the antenna be from vegetation, assuming LF/HF frequencies? Does the proximity of vegetation affect the radial system? Finally, is the type of vegetation or trees a factor in the effectiveness of this type of antenna?

**A** As far as I have been able to tell, foliage has minimal effect on HF, but does significantly attenuate 2-meter and particularly higher frequency signals. So likely there is more effect at 10 meters than at 80 — but I am not aware of any studies providing definitive numbers. I am vaguely aware of some research conducted in the '60s to try to couple HF signals to trees, as a method of providing stealth antennas for special operations forces in Vietnam. They were apparently unsuccessful, suggesting that trees — at least those trees — were not particularly conductive.

I have many trees in my yard, including a 100-foot evergreen that holds up my 80-meter ground plane, which runs right against the trunk. It can outperform my 70-foot-high horizontal dipole for low angle work. My 35-foot-high three-element HF tribander plus 6-meter Yagi radiates through heavy foliage at all azimuths, and together, they seem to work fine — on the other hand, I have no way to do an A/B comparison. Although, I seem as successful as others, and sometimes get through DX pileups quite quickly.

So, while I’m confident that the trees don’t provide any gain at HF, I don’t believe trees are a big problem. On the other hand, I can’t prove or quantify any effect that trees have. If anyone has access to definitive data on this topic, or has made comparisons, I’d appreciate a pointer, because this question comes up fairly frequently.
Typical: Verticals Near a Tree

An example of vertical antennas near large trees:

The G3NPC four-square array for the 15 m band

Source: https://www.qrz.com/db/g3npc
We Rose to the Challenge to Answer the DOC’s Questions

• First we found the electrical parameters of Live Trees

• Next we simplified the model to just one live tree trunk near a vertical dipole

• We used two independent methods:
  • Numerical Electromagnetic Code (NEC), and
  • an Electromagnetic Analysis of a lossy cylinder
  • Both methods were validated by measurements
The Tree Trunk is a Lossy Dielectric Cylinder Like People

“The electrical parameters of live trees are dramatically different than those for dead wood or lumber and vary with tree type, so we carried out our simulations over a range of dielectric parameters.”

<table>
<thead>
<tr>
<th>Tree Type</th>
<th>Permittivity Range</th>
<th>Conductivity, S/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Softwood, parallel to wood grain, or random polarization</td>
<td>46 – 72</td>
<td>0.17</td>
</tr>
<tr>
<td>Hardwood, parallel to wood grain, or random polarization</td>
<td>32 – 59</td>
<td>0.17</td>
</tr>
<tr>
<td>Softwood, perpendicular to wood grain</td>
<td>38 – 56</td>
<td>0.012</td>
</tr>
<tr>
<td>Hardwood, perpendicular to wood grain</td>
<td>12 – 31</td>
<td>0.012</td>
</tr>
<tr>
<td>Nonliving wood</td>
<td>2 – 9</td>
<td>&lt;0.008</td>
</tr>
<tr>
<td>Human muscle tissue</td>
<td>200 – 92</td>
<td>0.60 – 0.66</td>
</tr>
<tr>
<td>Saline water at 4 gm/L NaCl</td>
<td>79</td>
<td>0.63 – 0.69</td>
</tr>
</tbody>
</table>
Validated by *Measurements* on People and Lossy Cylinders

The Live Tree Trunk is a Lossy Dielectric Cylinder Near a Dipole
We Simplified to a Dipole Near an Isolated Tree Trunk

- Varied tree dielectric parameters over a range
- Varied the tree trunk height [including infinite height]
- We recorded:
  - loss vs. separation
  - front-to-back ratio vs. frequency
  - Yagi-Uda gain effect
We Chose Electrical Parameters of a Typical (Nominal) Tree

Our “nominal tree” was 0.33 m radius [like an 82 inch waist line], with dielectric constant of 52, and conductivity of 0.17 S/m.

Earlier measurements by Rudy Severns, N6LF, confirmed our choice of nominal values.

We then varied the parameters around the nominal values.

Source: Rudy Severns, N6LF
A Dipole at ZERO Separation from the Nominal Tree Trunk

Loss vs. Frequency

- Analytical results only
- Losses increase with frequency

Frequency, MHz

Loss, dB

10

1

10

100

1000
Losses vs. Distance for a Dipole Near a Tree at 14 MHz

- Fat Tree: large loss variation for different tree diameters
- Nominal
- Thin tree

Distance vs. Loss dB

- NEC
- Analytical
A Dipole 0.2 Wavelengths from a Tree looks like a 2-element Yagi

the curves are for different tree heights, at 14 MHz

NEC

Analytical
A Forest of Trees

Our Conclusions

- A tree trunk absorbs energy from a close-by vertically polarized antenna
- Loss increases with tree diameter
- Loss diminishes quickly with distance — “keep 0.3 $\lambda$ away for $< 1$ dB loss from one tree”
- Horizontal polarization is not affected by this loss, but vegetation affects all polarizations
- Limbs and vegetation scatter polarization
- The tree provides 4 – 6 dB **directive gain** at about 0.2 wavelengths separation
- A Forest provides multiple paths, additional losses
I hope that we’ve demonstrated the difference between Theory and Practice

“In Theory, we know everything, but nothing works”
“In Practice, everything works, but we don’t know why”
I hope that we’ve demonstrated the difference between Theory and Practice

“In Practice, everything works, but we don’t know why”
“In Theory, we know everything, but nothing works”

We combine Theory and Practice:

NOTHING WORKS, AND WE DON’T KNOW WHY!