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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and Richard Quick, W4RQ
— *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

Source: https://www.qrz.com/db/g3npc

An example of vertical antennas near large trees:

The G3NPC four-square array for the 15 m band

We Rose to the Challenge to Answer the DOC's Questions

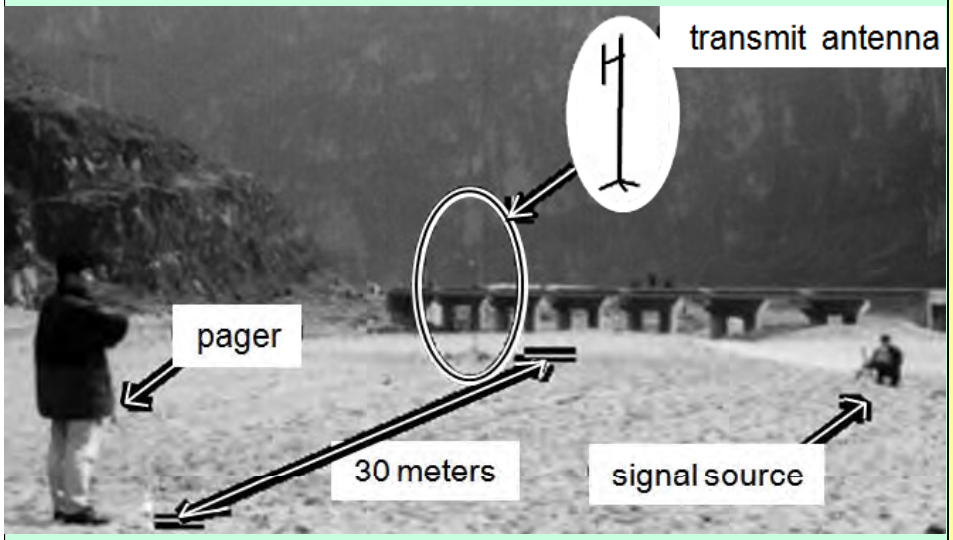
- First we found the electrical parameters of Live Trees
- Next we simplified the model to just one live tree trunk near a vertical dipole
- We used two independent methods:
  - Numerical Electromagnetic Code (NEC), and
  - an Electromagnetic Analysis of a lossy cylinder
  - Both methods were validated by measurements

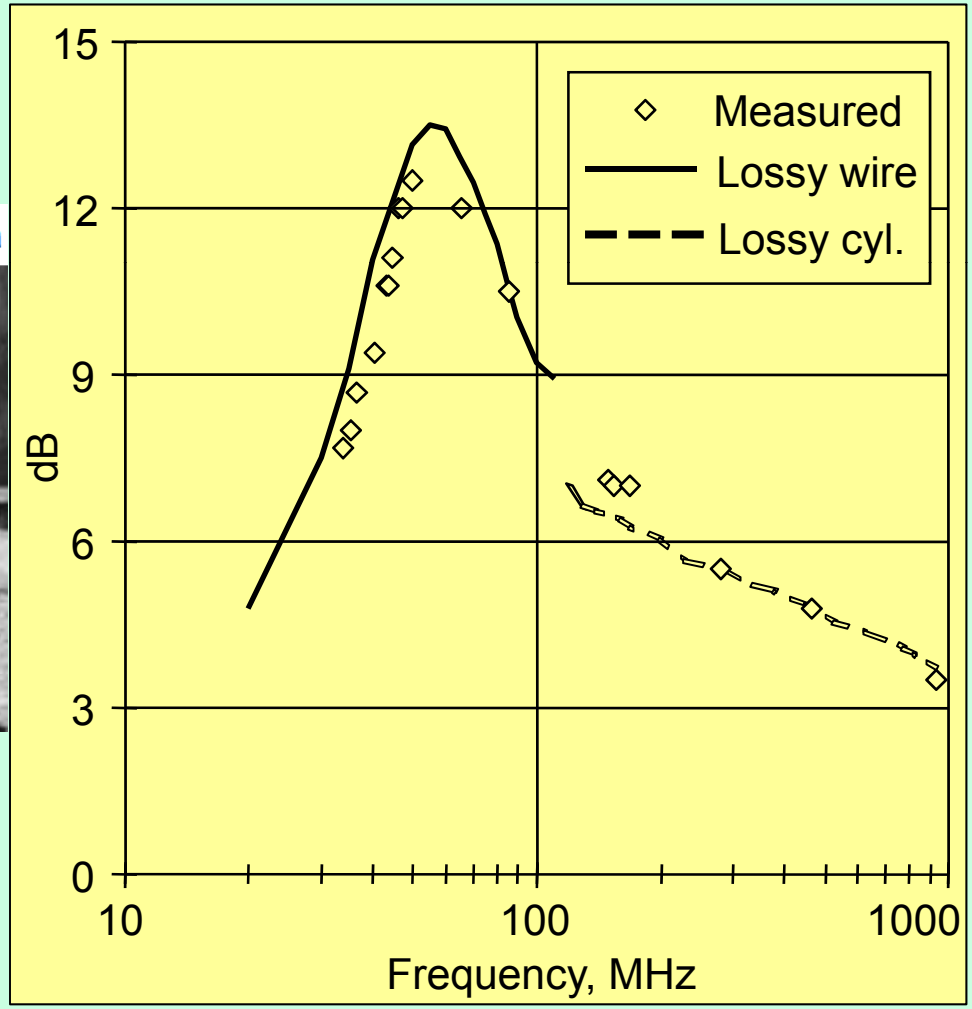
The Tree Trunk is a Lossy Dielectric Cylinder Like People

" 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. "

Tree Type	Permittivity Range	Conductivity, S/m
Softwood, parallel to wood grain, or random polarization	46 – 72	0.17
Hardwood, parallel to wood grain, or random polarization	32 – 59	0.17
Softwood, perpendicular to wood grain	38 – 56	0.012
Hardwood, perpendicular to wood grain	12 – 31	0.012
Nonliving wood	2 – 9	<0.008
Human muscle tissue	200 – 92	0.60 – 0.66
Saline water at 4 gm/L NaCl	79	0.63 – 0.69

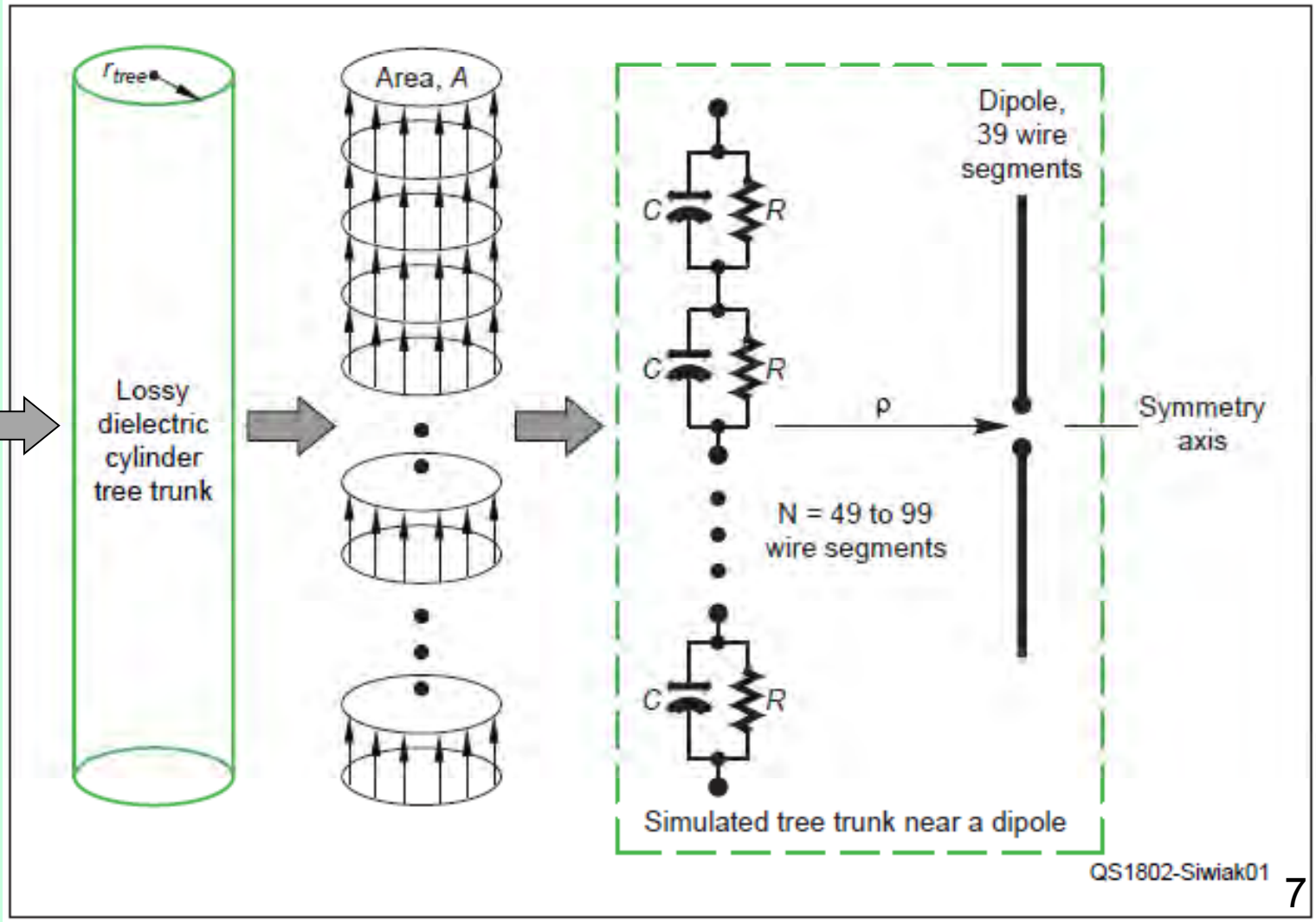
Validated by *Measurements* on People and Lossy Cylinders





Source:
Measurements in China: K. Siwiak and Y. Bahreini,
Radiowave propagation and Antennas for Personal Communications, 3rd Ed., Artech House 2007.

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

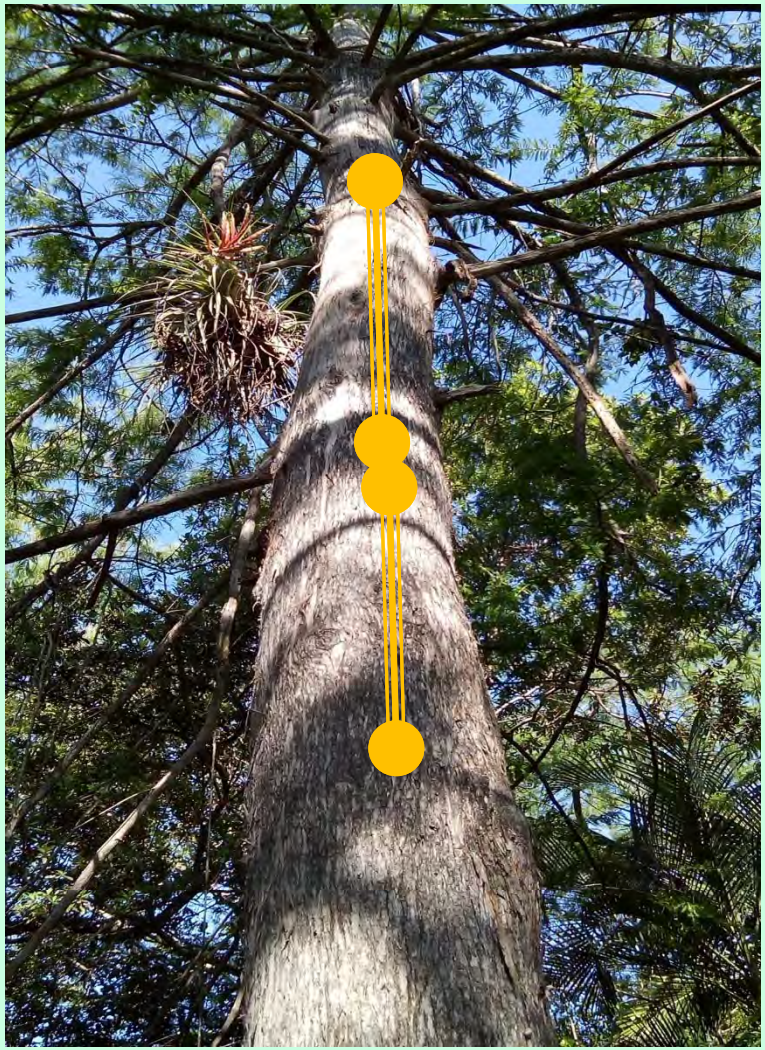
Our “nominal tree” was 0.33 m radius [like an 82 inch waist line], with dielectric constant of 52, and conductivity of 0.17 S/m

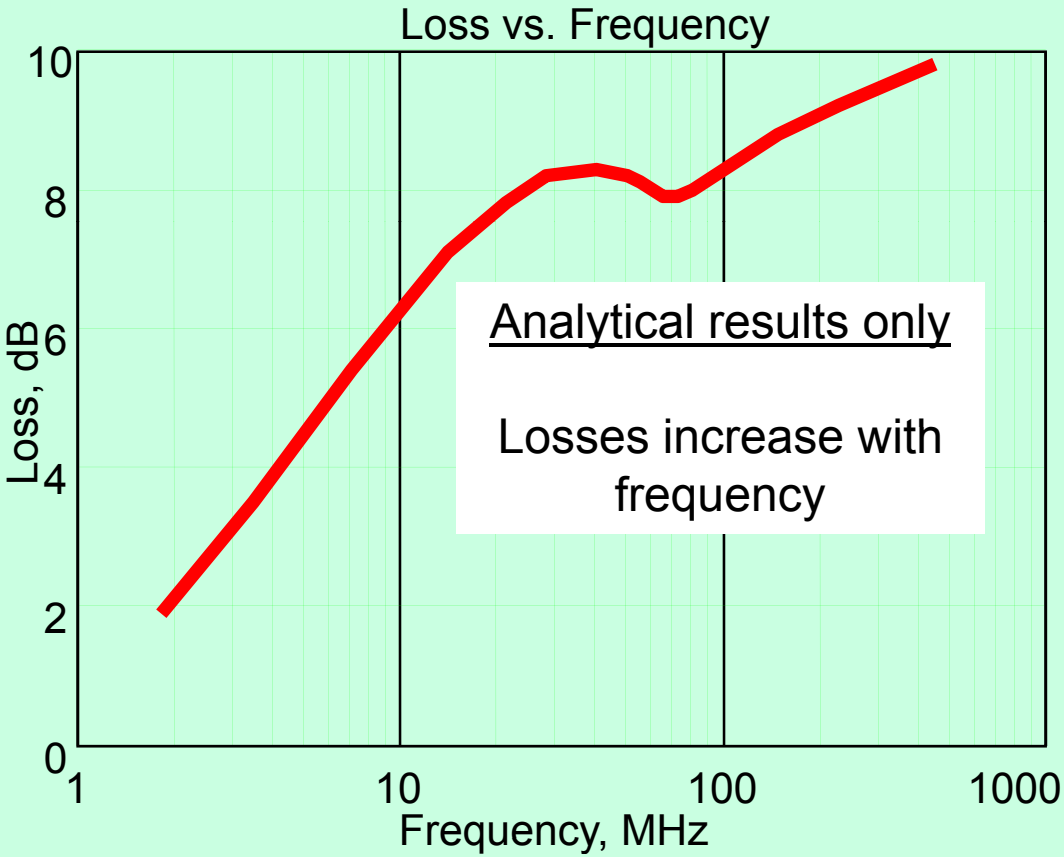
Earlier measurements by Rudy Severns, N6LF, confirmed our choice of nominal values

We then *varied* the parameters around the nominal values

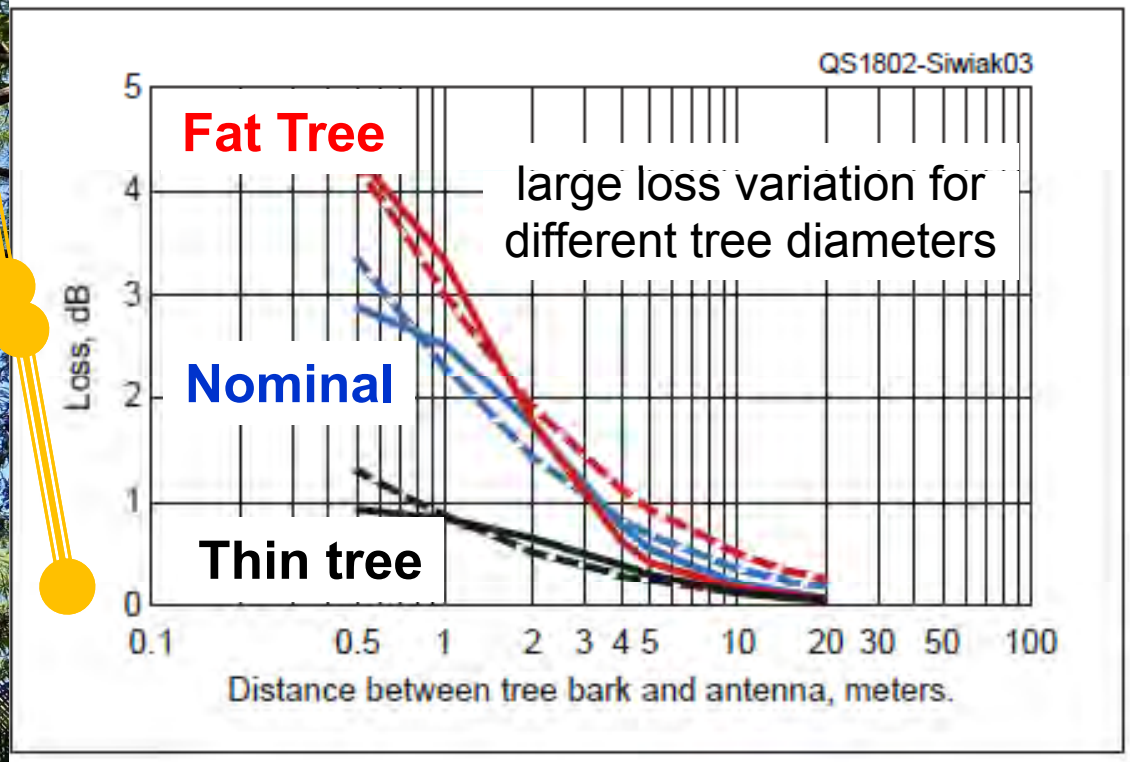
Source: Rudy Severns, N6LF

A Dipole at ZERO Separation from the Nominal Tree Trunk





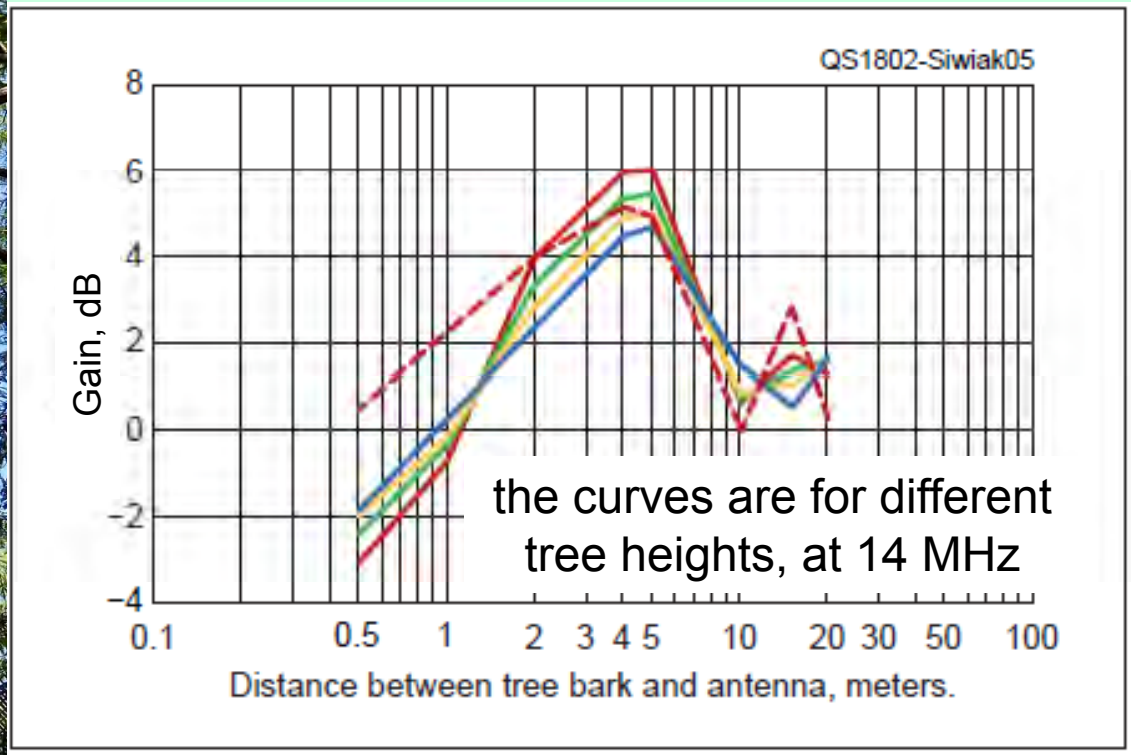
Losses vs. Distance for a Dipole Near a Tree at 14 MHz



NEC

Analytical

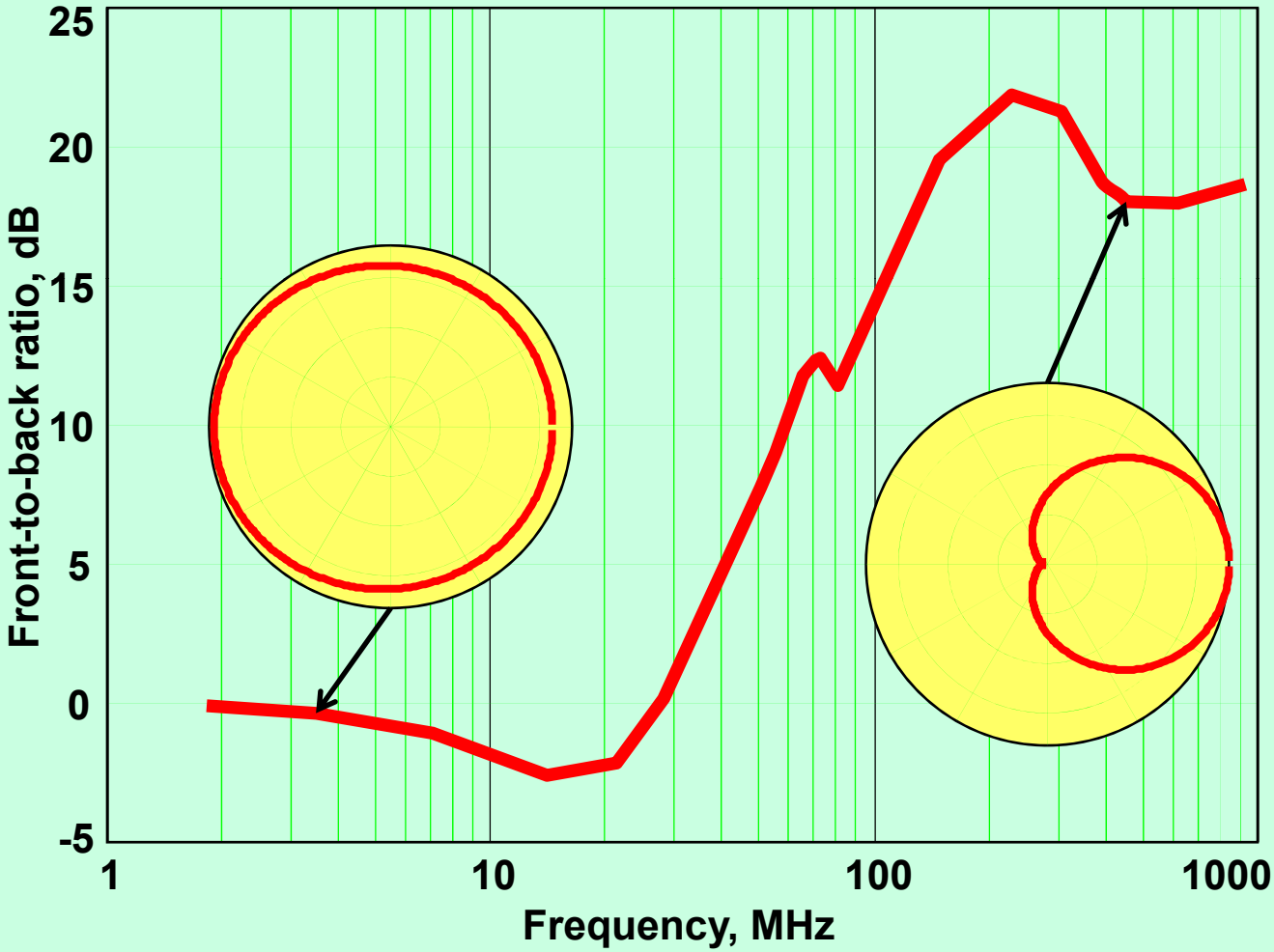
A Dipole 0.2 Wavelengths from a Tree looks like a 2-element Yagi



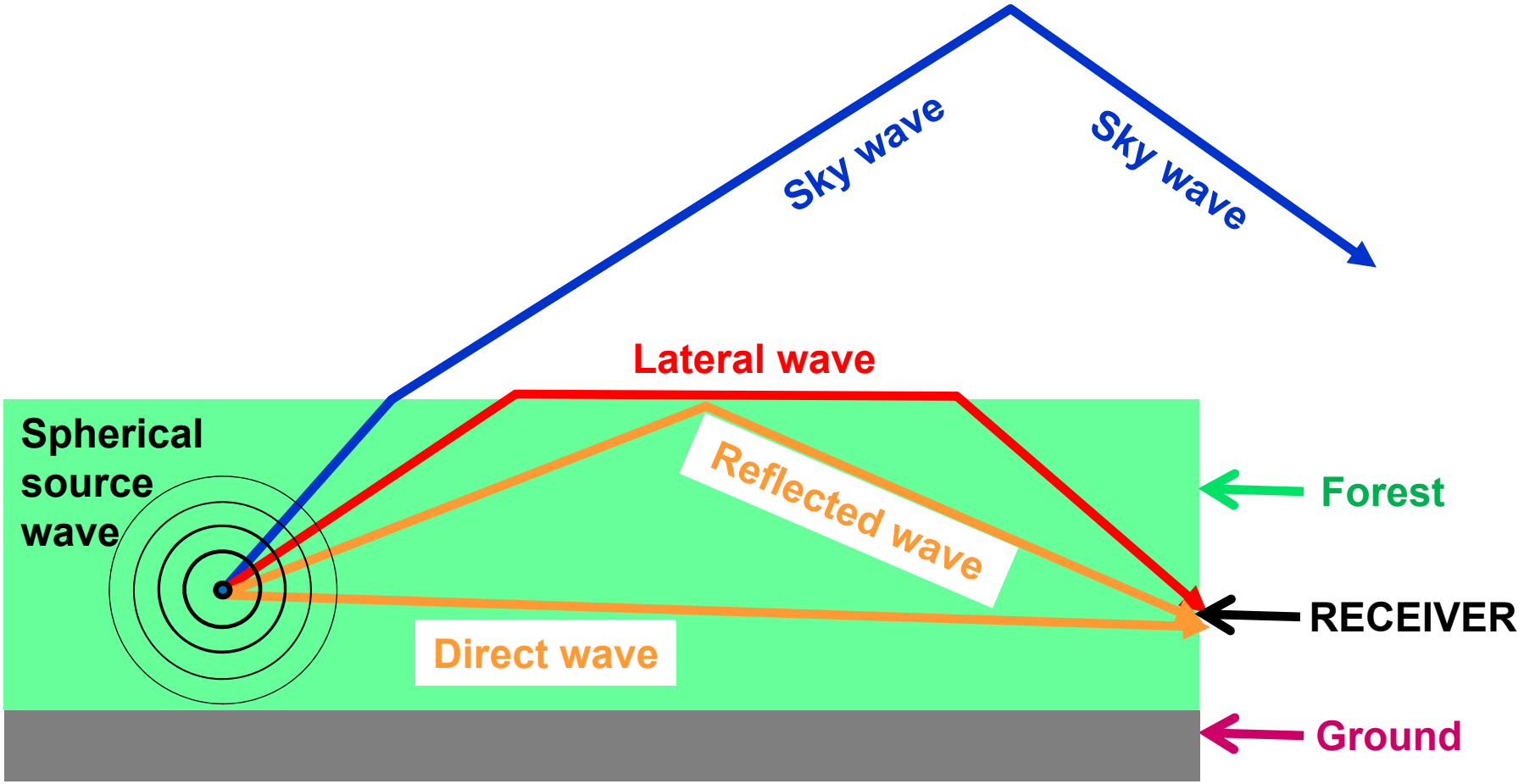
NEC

Analytical

Front to Back Ratio *vs.* Frequency



A Forest of Trees



Source: Theodor Tamir, "Radio Wave Propagation Along Mixed Paths in Forest Environments"; IEEE Transactions on Antennas and Propagation; AP-25, No 4,July 1977; pp .471-477.

A Forest of Trees

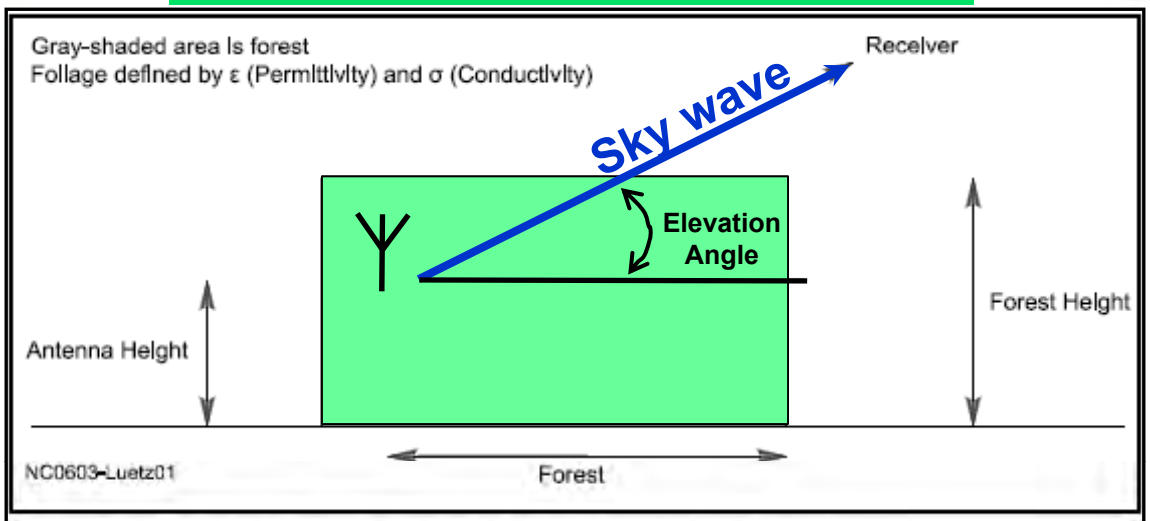


Figure 1—Theodor Tamir's model of an antenna in a forest.

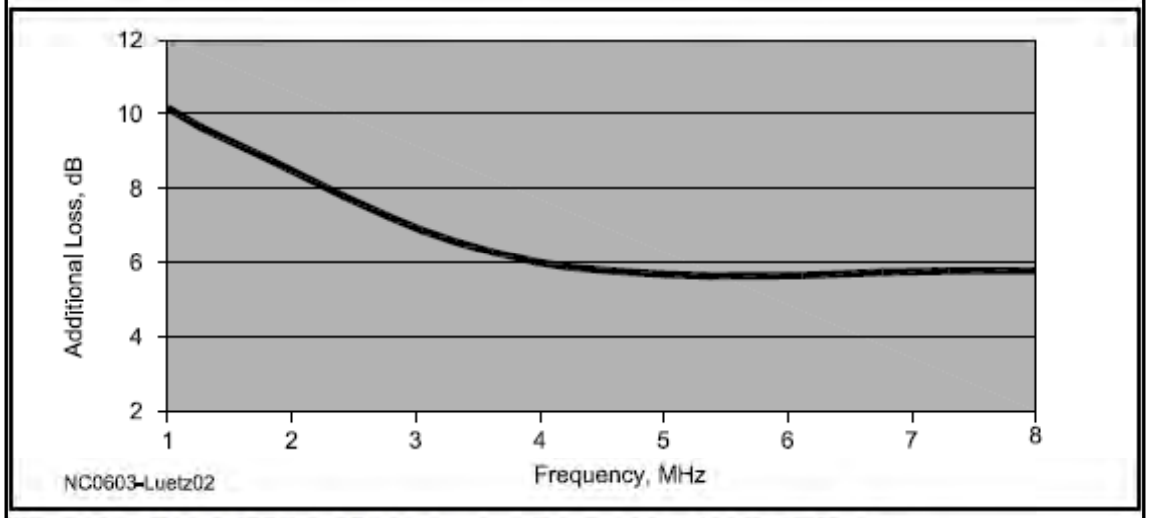


Figure 2—The additional loss versus frequency due to foliage.

Source: Carl Luetzelschwab, K9LA, "Propagation: Low Band Antennas and Trees" *NCJ,* Mar./Apr., 2006.

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 λ 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!