

# Forest and Vegetation Propagation

## Forest and Vegetation Propagation at 915 MHz

Vegetation is one of the most significant impairments to 915 MHz propagation. Forested terrain requires a fundamentally different planning approach from open or urban environments.

### Foliage Attenuation

915 MHz is significantly absorbed by vegetation. Specific attenuation through dense in-leaf woodland near 900 MHz is roughly **0.2 - 0.5 dB per meter** (ITU-R P.833 / Weissberger), i.e. about **20 - 50 dB per 100 m** of traversal. Importantly, the loss does *not* grow linearly without bound - it saturates beyond roughly 14 m of foliage depth, so very deep canopy adds less than a simple per-meter multiplication would predict. Typical losses:

Vegetation Type	Loss per 100 m of Traversal
Dense deciduous forest (summer, full leaf)	~20 - 50 dB
Coniferous forest (pine, fir)	Comparable - needle vs. broadleaf differences at 915 MHz are not well-characterized and depend on density and moisture; do not assume conifers are reliably lower (year-round dense, high-moisture canopy can be similar or higher)

Even a few hundred meters of dense forest can consume the entire link margin of a typical LoRa deployment. As a result, ground-level range in dense forest is often only 200 - 500 meters even with the longest LoRa spreading factors - this figure is derived from the loss budget and consistent with field reports, not a fixed measured constant, and actual range varies with antenna height, modem preset, and forest density.

### Seasonal Variation

Deciduous forests have dramatically different propagation in summer (full leaf) versus winter (bare branches). A link that works reliably in December may fail completely in July when the leaves are out.

**Always plan coverage for worst-case summer leafed-out conditions.** Links that are marginal in winter will likely fail in summer. If your network must work year-round, design for July.

## Elevation Above Canopy

The single most effective technique for improving range in forested terrain is getting the antenna above the tree canopy.

A node mounted at canopy level or just above it has near-line-of-sight to distant nodes that are also above the trees. Even clearing the canopy by roughly 5 - 10 meters dramatically improves range in forested areas (an approximate guideline - the benefit depends on canopy height and link geometry).

Node Position	Typical Range (derived / site-dependent)
Ground level in dense forest	~200 - 500 m (typical, derived from loss budget)
At or above canopy (~20 m elevation)	~5 - 10 km to other elevated nodes (typical example; clear-LOS LoRa links can far exceed this, dense conditions fall short)

This is a dramatic difference - illustrative of the order-of-magnitude benefit, the same hardware can perform roughly 10 - 20× better simply by being above the canopy. The exact multiplier is an illustration, not a precise measured figure.

## Trail Corridor Effect

Trails create linear openings in the forest canopy. Range along a trail is significantly better than off-trail in the same forest. The open sky corridor above the trail allows near-LOS propagation along the trail axis.

This is useful for planning hiking or trail mesh coverage - nodes near trail intersections or high points along trails will have better coverage than nodes placed arbitrarily in the forest interior.

## Mixed Terrain Path Budgets

When a link crosses both open and forested terrain, **plan for the worst-case segment.** A 10 km link that crosses 3 km of dense forest needs to be designed for the forest loss, not the open segments.

Use a simple approach: calculate the total forest path length in your link, apply a conservative **~40 - 50 dB/100m** for dense summer deciduous canopy (the high end of the 20 - 50 dB/100m range is the conservative worst-case planning value; note the loss saturates beyond ~14 m depth), and verify the total loss fits within your link budget. If it doesn't, raise antenna height or use a higher-gain antenna. (Transmit power is already at the radio's ~22 dBm chip maximum on standard mesh hardware; FCC Part 15.247 caps conducted power at 30 dBm and EIRP at 36 dBm, and antennas above 6 dBi require a dB-for-dB power reduction - so there is little legal headroom to simply "turn up the power.")

## Summary for Forest Deployments

- Mount antennas as high as practical - at or above canopy height
- Test and plan for summer worst-case conditions
- Use trail corridors for coverage where possible
- Account for every meter of forest in your path budget
- Consider tower or tall-tree mounting for backbone nodes

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