

Nee et al., 1994

Richel Bilderbeek 

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## 1 Likelihood

The likelihood calculation is based on Nee et al., 1994.

To calculate the likelihood of a phylogeny and parameters, the phylogeny is cut into pieces (1), as all we need are braching times ( $ts$ ) and branch lengths ( $xs$ ). The shape of the tree is unimportant for this model.

$$u(\lambda, \mu, x) = \frac{\lambda(1 - \exp(-(\lambda - \mu)x))}{\lambda - \mu(-(\lambda - \mu)x)} \quad (1)$$

$$P(\lambda, \mu, t, T) = \frac{\lambda - \mu}{\lambda - \mu \exp(-(\lambda - \mu)(T - t))} \quad (2)$$

$P(\lambda, \mu, t, T)$  is the chance a lineage alive at time  $t$  is still present at time  $T$ . The likelihood function, equation 3, is:

$$\mathcal{L}(\lambda, \mu, ts, T) = (N - 1)! \left[ \prod_{i=3}^N P(\lambda, \mu, t_i, T) \right] (1 - u(\lambda, \mu, x_2))^2 \left[ \prod_{i=3}^N (1 - u(\lambda, \mu, x_i)) \right] \quad (3)$$

## 2 Acknowledgements

Thanks to César Martinez for helpful discussion.

## 3 References

- Nee, Sean, Robert M. May, and Paul H. Harvey. "The reconstructed evolutionary process." *Philosophical Transactions of the Royal Society B: Biological Sciences* 344.1309 (1994): 305-311.

Symbol	Description
$\mathcal{L}$	Likelihood
$\lambda$	Speciation rate
$\mu$	Extinction rate
$N$	number of lineages at the current time, time $T$
$t_1$	Root time
$t_2$	Crown age, time of first branching
$t_i$	Time of $(i - 1)$ th branching, $i \in [1, N]$
$ts$	Vector of branching time, $ts = \{t_1, t_2, \dots, t_n\}$
$T$	Current time
$x_2$	Time between $t_2$ and $T$ , time since first branching, $i \in [1, N]$
$x_3$	Time between $t_3$ and $T$ , branch length of branch originating at $t_3$
$x_i$	Time between $t_i$ and $T$ , branch length of branch originating at $t_i$
$xs$	Vector of branch lengths, $xs = \{x_1, x_2, \dots, x_n\}$

Table 1: Symbol descriptions

Original number	Original form	Equation number	Form used here
1	$u_t$	1	$u(\lambda, \mu, x)$
2	$P(t, T)$	2	$P(\lambda, \mu, t, T)$
20	$lik$	3	$\mathcal{L}(\lambda, \mu, ts, T)$

Table 2: Equation comparisons of the original equations by Nee et al., 1994 and the numbers and form used here

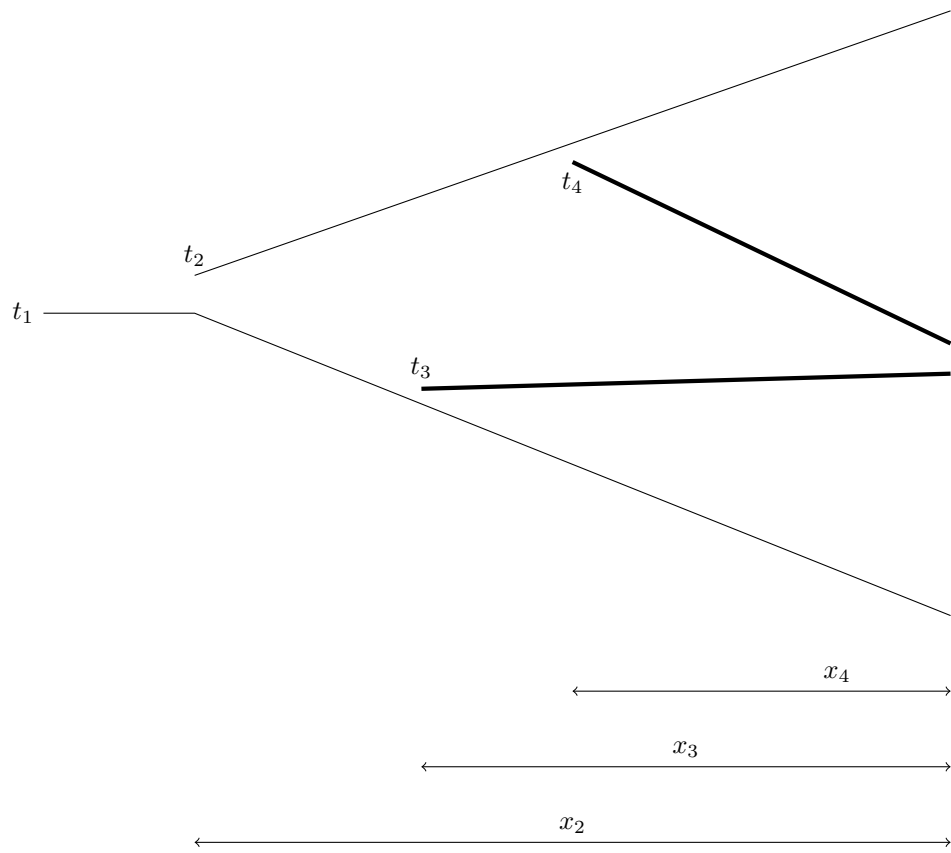


Figure 1: Tree similar to figure 2 of Nee et al.