Estimating true ranges of fossil taxa from stratigraphic data when recovery potential is not uniform

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Paleontologists often want to determine the time of extinction of a fossil taxon (e.g., a kind of dinosaur). However, this task is made difficult by the incompleteness of the fossil record. For example, the dinosaur below is known from 5 fossil specimens, the most recent of which is dated to 66 million years ago:

70   69   68   67   66   65
millions of years ago

Thus this dinosaur species went extinct more recently than 66 million years ago. But since there are gaps in the fossil record, it is possible that the dinosaur existed later than that time, and we are simply missing its fossils. In other words, the known stratigraphic range of a taxon most likely underestimates its true range.

   If we assume the probability of finding a fossil—the recovery potential—is uniform throughout the taxon's true range, then it is straightforward to estimate the true time of extinction. This assumption is often invalid, however, due to variations in rock availability or taxon abundance. Our goal is to derive a confidence interval for the true time of extinction without assuming uniform recovery potential, and without requiring *a priori* knowledge of the recovery potential (as some existing methods do).

low likelihood   high likelihood
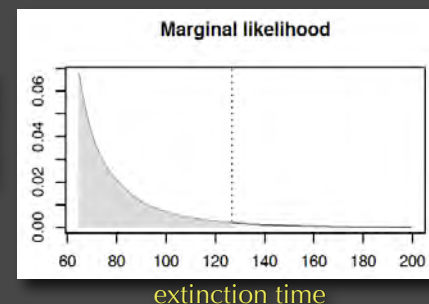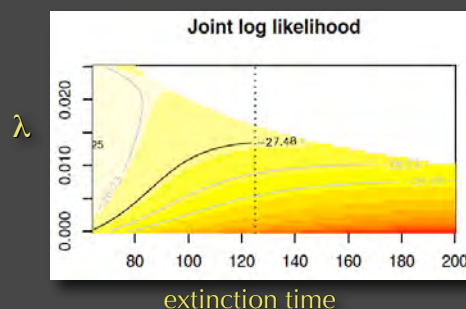
OUTLINE OF METHOD

1. Calculate joint likelihood of λ and extinction time

2. Integrate out λ (shape parameter) to get likelihood of extinction time

3. Posterior distribution on extinction time
   = Prior belief × Likelihood

4. CI endpoint = 95th percentile of posterior distribution