Chapter 7

Paper:

Jaramillo, Carlos, Milton J. Rueda, and German Mora. "Cenozoic plant diversity in the Neotropics." *Science* 311, no. 5769 (2006): 1893-1896.

Questions:

1. **The mechanisms leading to high tropical plant diversity are hotly debated. What are some of the leading hypothesized mechanisms?** ANSWER: (1) The tropics are old – e.g. the dominant taxa in tropical forests have deep evolutionary histories and so have had longer to speciate than other biomes; (2) A combination of low extinction rates and high origination rates of species over long geological time scales; (3) Rapid glacial-interglacial cycle driven speciation events.

2. **This paper aims to reconstruct the history of Neotropical plant diversity. What aspect of the fossil plant record has been investigated to fulfil this aim?** ANSWER: The record of macrofossil plants (e.g. leaves, fruits, flowers etc.) is too sparse in time and space so the authors have used fossil pollen and spores extracted from 1530 sediment samples collected from 15 different stratigraphic sections across Columbia and western Venezuela.

3. **How was plant diversity estimated for each successive time interval studied?** ANSWER: The raw dataset on which the diversity estimates are based are 287737 individual fossil pollen and spores extracted from sediment with a known stratigraphic position. Each observed spore or pollen grain was then assigned to a fossil morphospecies based on overall pollen/spore morphology. All species which were represented by only a single pollen grain or spore were removed from the dataset (these are referred to as singletons) because they can inflate the diversity estimate and could potentially represent contamination from other sources.
   An age estimate was assigned to each sediment sample containing pollen and spores using a combination of dating approaches (isotope stratigraphy, foraminiferal calibration points and well known stratigraphic datums) and assuming that the rate of sedimentation between known stratigraphic datums was linear. The number of spores and pollen grains occurring per stratigraphic interval was then added up to provide an estimate of diversity using the 'range through method'. This method basically assumes that a species lived in between its first occurrence recorded in the fossil record and its last occurrence. Therefore the estimate of diversity is based on the total number of species and morphospecies which 'range through' each time interval.

4. **The fossil pollen and spore diversity data was compared with diversity data obtained for the Holocene (last 10,000 years). Why and how was this comparison undertaken?** ANSWER: The plant diversity estimates based on fossil pollen and spores could have been compared directly with the known species diversity of living Neotropical forests in

© Oxford University Press, 2014.

Columbian and Venezuela. This comparison would have been invalid, however, because you would not be comparing 'like with like'. In order to get an estimate of recent Neotropical diversity subjected to similar biases as that of the fossil pollen and spore diversity record the authors cored Holocene-aged sediments and estimated the diversity of Holocene vegetation from their pollen and spore record. This was undertaken as a means of benchmarking the palaeo diversity data with modern diversity data pre-Human influence but subjected to the same general biases.

5. **Holocene and pre-Holocene diversity estimates were also compared using a rarefaction analysis. What is rarefaction and what are the advantages of using this method to estimate palaeoplant diversity?** ANSWER: Rarefaction analysis is a method of estimating species richness which takes into account the number of individuals collected per species (i.e. the relative abundances of species) and the total number of specimens collected per sample. It is an important method in palaeoecology because it allows you to account for the fact that some samples or localities will yield more individual pollen and spores than others – something that could potentially bias the final plant diversity estimate. Rarefaction analysis allows the researcher to assess whether the true diversity of a sample has likely been estimated or whether further sampling is needed to obtain a diversity value closer to the true value.

6. **Describe the pattern of neotropical plant diversity obtained from the fossil pollen and spore record.** ANSWER: Low floral diversity is observed in the early Palaeocene. A sharp positive excursion in diversity is observed in the late Palaeocene followed by a steady rise up to the middle Eocene, where peak diversity occurs. A steady decline follows the peak Eocene diversity to the Oligocene, with further declines into the Miocene.

7. Why **does the paper suggest a causal relationship between long-term trends in global temperature and in Neotropical Plant diversity?** ANSWER: A strongly significant temporal correlation is observed between the plant diversity trends and the proxy global temperature record (based on $\delta^{18}O$).

8. **What hypothesized mechanisms do the authors put forward as an explanation for this causal link between temperature and diversity?** ANSWER: The authors propose two main mechanisms: (1) CO_2 driven changes in diversity: Because CO_2 and global temperature are coupled on long time scales they suggest that the coincidence of changes in diversity and global temperature is indirect and driven by CO_2, which would influence both global temperature (via the greenhouse effect) and potential biodiversity (through a CO_2 fertilization effect); (2) Species-area driven changes in diversity: The authors suggest that during times of high global temperatures the geographical extent of tropical climates and vegetation was much greater. Larger geographical areas can support greater species diversity which in turn would boost local and regional diversity.

9. **Are you surprised by the fact that Holocene diversity levels were found to be lower than those in the Eocene?** ANSWER: Student's own opinion.

© Oxford University Press, 2014.