

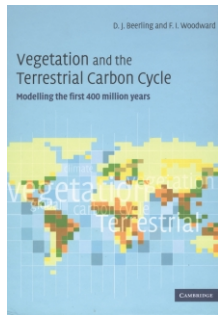
Modeling plant history

Vegetation and the Terrestrial Carbon Cycle: Modeling the First 400 Million Years

by D.J. Beerling and F.I. Woodward.

Cambridge University Press, 2001.

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Plants have existed on Earth for >400 million years (My). Over this time, CO₂ concentrations have fluctuated between several hundred and several thousand parts per million,

the climate has ranged between conditions resembling a snowball and those resembling a hot and humid greenhouse; oxygen levels have swung between 10% and 35%; continents have moved, plates have been subducted or uplifted and soils have evolved and have been scraped clean by glaciers. For several years, David Beerling and Ian Woodward have speculated how plants, the Earth and its atmosphere have interacted over the past 400 My. For example, they reported on a link between a major extinction event and unfavorable leaf temperatures maintained by plants with large leaves at the Triassic–Jurassic boundary. Now, these authors have expanded upon their original theories and have produced *Vegetation and the Terrestrial Carbon Cycle: Modeling the First 400 Million Years*.

Their aim is to ‘investigate the past from the present’. The key assumption on

which this premise is based is that plants are subject to the same physical, chemical and biological laws today as they were when they evolved 400 My ago, only the conditions to which they have been exposed have changed. Consequently, the authors use a contemporary photosynthesis model that evaluates the carboxylation and oxygenation rates of the enzyme Rubisco, as the cornerstone of their theory. Another key assumption is that the paleo-record can be used to deduce how stomatal density and stomatal conductance has varied over geological time, as ambient CO₂ levels rose and fell. They use this combined information to evaluate leaf energy and soil-water balances.

Beerling and Woodward address several interesting topics, including the impact of high (35%) oxygen and fires during the Carboniferous, changes in leaf physiognomy during the Cretaceous–Tertiary boundary, the introduction of C4 plants during the Eocene and the impact of low CO₂ and glaciation during the Quaternary.

Some skeptics might criticize an analysis of plant–climate interactions during geological time as an exercise in playing with models. But I disagree – this is what models are designed to do. Biogeochemical models give us insights on how complex ecosystems behave when we are unable to measure them directly. The authors use state-of-the-art models and make a concerted effort to support their computations using the fossil record and isotopic measurements. The computations seem accurate based on the fact that the model can reproduce, in a general sense, the temporal variation of ¹³C in the fossil

soil and coal, laid down over 400 My, which varied between about –21 and –28%.

The discussion of the role of extra-high oxygen levels on plant–atmosphere interactions during the Carboniferous period, as proposed by Berner [1], is probably the most controversial aspect of this book. Lenton [2] recently criticized this model on the basis that a feedback between combustion and oxygen prevents oxygen levels from reaching such high levels and that elevated oxygen levels promote photorespiration.

The book is pioneering, thought provoking and scholarly, reflected in its presentation of up-to-date ideas about the evolution of the atmosphere and the migration of continents, as well as contemporary developments in ecophysiological theory. If there is a weakness, it is that some of the later chapters become repetitive. The bottom line is that, if you are interested in plant–atmosphere interactions, then this book is worth reading.

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- 2 Lenton, T.M. (2001) The role of land plants, phosphorus weathering and fire in the rise and regulation of atmospheric oxygen. *Glob. Change Biol.* 7, 613–629

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