Preface

The Simojovel resident lowered his gun, smiled broadly if somewhat sheepishly, and said, "Puedes beber de mi pozo." His welcome culminated a long morning of discussion near a bluff bordering the village cemetery. Although unsettling, there had been a faint overlay of conviviality throughout the encounter—the villagers knew we probably meant no harm, and we guessed they probably were not going to execute us, however convenient the site. We had come to the village of Simojovel to collect rock samples. The bluff was an exposure of the La Quinta Formation in an area of Chiapas, Mexico, famous for the plant and animal inclusions of its amber deposits. Mining rights to the amber had been ceded to local residents, and although there was no amber at this site, our presence was an opportunity to demonstrate rightful authority, and to pass an otherwise uneventful morning conversing and good-naturedly harassing strangers from afar. It took awhile to explain that we really had come thousands of miles to collect rocks of no apparent value from which we would extract spores and pollen to reconstruct climates and vegetation that had not existed for millions of years. Convinced we were probably more harmless than devious, we were eventually accepted with the local greeting, "You may drink from my well."

Generations of resident scientists and foreign visitors have been observing and studying the natural history of the New World for five hundred years. This book summarizes the results of that research as they apply to the formation of ecosystems over time in response to changes in geology and climate acting on evolutionary processes. A convenient organizational framework is provided by three drops in temperature that divide the past 100 million years into four time segments: Late Cretaceous through the early Eocene (100 million to 50 million years ago), middle Eocene through the early Miocene (50 million to 16.3 million years ago), middle Miocene through the Pliocene (16.3 million to 2.6 million years ago), and the Quaternary (2.6 million years ago to the present). Each was an eventful period during which great changes took place in the Earth's flora, fauna, landscape, and climate. The record of these changes begins here with a Cretaceous world dramatically different from the present, and one from which the evolution of new life-forms, fluctuations in the environment, and gradual uniformitarian and sudden catastrophic events shaped the Earth's surface and its living envelope. It has been a lengthy, immensely complex, delicately balanced, and highly interactive process.

In this account I focus on vegetation, for three principal reasons. First, plants are the conspicuous, conveniently stationary component of the Earth's ecosystems and are most often used to name or characterize the systems (boreal forest, mangroves, savanna). Second, plant fossils are abundant and have been used extensively to reveal the history of lineages and communities—their origin, evolution, migration, and the time relationships between them—and to reconstruct the Earth's paleoenvironments. Last, much of the literature and many natural history presentations intended for general audiences understandably feature charismatic, exotic, dangerous, attacking animals harassed by film crews and wannabe celebrity naturalists. This makes for good theater, and it admirably focuses attention on selected treasures of the biological kingdom, but on another level, it gives only a partial picture of the Earth's ecosystems, and it is not a broad enough basis for a meaningful consideration of their structure, function, importance, conservation, and sustained management. Plants provide the oxygen we breathe, the food we consume, the fossil fuel that both supports and threatens our civilization, and the habitats within which all life coexists. For those seeking a fuller understanding of the Earth's web of life and a rational agenda for ensuring its continuation, this should be emphasized.

In *The Eternal Frontier: An Ecological History of North America and Its Peoples* (2001), Tim Flannery offers a complementary account of the biota of North America, describing especially well the history of its fauna and people. The mammals are equally well summarized by Michael Woodburne in *Late Cretaceous and Cenozoic Mammals of North America* (2004), and by

Christine Janis and others in the two-volume *Evolution of Tertiary Mammals of North America* (1998, 2008). My account here stresses the critical role of plants and time.

In two earlier summaries I address North America north of Mexico (Graham 1999, or I) and Latin America (Graham 2010, or II). These works contain detailed information and references and may be consulted as needed for background to the present text. To reduce repetitious citation, they are referenced here as I and II. In addition, there are edited summaries of the floristic relationships with eastern Asia (Graham 1972) and the vegetation and vegetation history of Latin America (Graham 1973, 2006). The present text is a combined version of these and other works, especially the 1999 and 2010 treatments, and it draws freely on them. This book differs in that although it serves as a summary for specialists in vegetation history, it is also intended for a broader audience of specialists in other fields, as well as students who have an interest in the New World and how it got that way. It brings the references and Web addresses from 1999 and 2010 up to date, although protocol identifiers, domains, and pathways are subject to change. The text also includes new information on climates, fossil faunas, mountain uplift, global sea level change, and paleotemperatures. There have been intriguing new discoveries, such as tapir and crocodilian lineages in the early Eocene of the High Arctic, and the gargantuan boid *Titanoboa cerrejonensis*, thirteen meters long and weighing over a ton from the Paleocene of Colombia (Head et al. 2009). The latter find suggests that the mean annual temperature (MAT) in the neotropical lowlands may have been considerably warmer than the present, about 28°C (but see Sniderman 2009). If so, this has implications for the steepness of Paleogene thermal gradients, ocean circulation, and the migration of some tropical and subtropical species out of an equatorial zone that may have been too warm. There is also recent evidence for an explosive emission of methane gas from the Norwegian Sea that goes a long way in explaining the extraordinary rise in global temperature around 55 million years ago (Ma). A current trend, still to be confirmed in its details, is to recognize uplift of the Rocky Mountains and the Sierra Nevada to greater heights, at least locally, and earlier (in the Eocene, about 45 Ma) than suggested in the older literature (primarily in the Oligocene and Miocene, 30 Ma onward). By contrast, the great heights of the Andes Mountains (altitudes above about 2000 m) are now generally acknowledged as coming comparatively late in geologic time (after about 10 Ma). In addition, Cretaceous seas may not have been as high as earlier thought (possibly at times only 100 m or more higher than at present, rather than uniformly reaching 300 m), perpetuating some still mostly unsubstantiated models predicting extensive Cretaceous glaciations.

This text is unique in its coverage of the New World as a single geographic unit. This treatment is desirable because the continental interchange of biotic elements helped shape the ecosystems of northern North America, Mexico, the Antilles, Central America, and South America. The text is also a single authored treatment, rather than an edited summary. This affords the advantage of a unified perspective while acknowledging the many inherent challenges in that approach.

As an aid to following the development of New World environments and biotas through time, a geologic time scale appears as the frontispiece (after Gradstein et al. 2005). The status of the Quaternary has recently been the subject of considerable debate, including a proposal that it be abandoned entirely and included in the Late Cenozoic (Giles 2005; Mascarelli 2009). The International Commission on Stratigraphy recommended in May 2009 that the boundary be set at 2.6 Ma. For the moment, the Quaternary is defined as follows:

- Quaternary 2.5/2.6–0 Ma
  - Holocene (or Recent) 11.5–0 kyr (thousand years BP)
  - Pleistocene 2.5/2.6 Ma–11.5 kyr
    - Late glacial 21–11.5 kyr
    - Last Glacial Maximum (LGM) 21–18 kyr (19/20–26.5 kyr; Clark et al. 2009)

The arrangement of continents at 100 Ma is shown in figure 2.19, a global sea level curve in figure 3.1, and a global paleotemperature in figure 3.4. Conversion tables for measurements are available at several Web sites (e.g., www.onlineconversion.com).

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For most of us there is something fascinating in how communities of living systems came about and the vast eons of time it took for them to reach their present status. There is usually some curiosity about how the information is obtained and an admiration for the persons who obtained it once their often heroic efforts are known. It is hoped, as the world's ecosystems become better understood, that there will also be an enhanced feeling of respect for what they represent and a growing insistence that they be sustained.

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Additional Readings and Updates

Barrionuevo, A. 2008. Forest plan in Brazil bears the traces of an activist's vision. *New York Times*, 22 December 2008. ["Twenty years ago, a Brazilian environmental activist and rubber tapper was shot to death at his home in Acre State by ranchers opposed to his efforts to save the Amazon rain forest. After his death at age 44, Francisco Alves Mendes, better known as Chico, became a martyr for a concept that is only now gaining mainstream support here: that the value of a standing forest could be more than the value of a forest burned and logged in the name of development."]

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