Preface

> Understanding present-day ecosystems must include the concept of time. The fullest understanding of this world, its origin, current status, trends and future will come from the seamless integration of neobiology with paleobiology, and a knowledge of the environmental dynamics that drive the process of change.
> – Alan Graham, *A Natural History of the New World* (2011)

The landscape of the Olympic Peninsula in northwest Washington is impressive from every angle. A distinct geographic area bordered by the Pacific Ocean, the Strait of Juan de Fuca, and the Puget Lowlands, the peninsula marks the southern end of a cool-temperate rainforest ecosystem that extends along the archipelago of coastal islands of British Columbia and southeast Alaska. It also contains high-relief mountains, a gradient of rainfall unmatched anywhere in the coterminous USA, forests capable of producing some of the largest and oldest trees in the world, and a distinct biota marked by endemic species. It is this complex geography that has resulted in a unique accumulation and exclusion of biotic diversity on display across the peninsula.

The complex arrangement of ecosystems within the Olympic Peninsula is normally described as a product of the regional climate and geology. However, at a finer resolution, say of a tributary of a major river, one may see that the exact pattern of forest cover is the result of a history of fires in certain years and windthrow in other years (Peterson et al. 1997a). Similarly, if one focuses on a single species, the pattern of its presence and absence over space may be as much a result of environmental gradients as of its recent history of response to disturbances and interactions with other species. Because of the long timescales over which these processes occur on the Olympic Peninsula, making sense of the biotic patterns in this area, or in any geographic area dominated by long-lived species, requires a historical perspective. What events, especially those related to past climate changes and disturbances, have led to the occurrence of the present set of species and its current distribution? Obtaining answers to this question has never been more important than it is today. The rapid climate changes currently underway are unlike any during the last 11,000 years (Marcott et al. 2013), and the potential impact of these climate changes on the biota is difficult to gauge (McMahon et al. 2011).

Changes in climate and vegetation over millennial time scales are fundamental for understanding the assembly of natural communities. Paleoecology, the study of past environments using fossil evidence, not only reconstructs past ecosystems (e.g., species composition, habitat types, etc.) but also addresses ecological questions that cannot be unraveled over timescales of the human lifespan (Schoonmaker and Foster 1991). Paleoecologists tackle several challenges in understanding the biotic response to climate and other agents of ecosystem change that are particularly relevant to the Olympic Peninsula. First, changing disturbance regimes mediates species responses to climate change. Paleoecological studies in the western US have been addressing this issue by using detailed charcoal stratigraphy of fire events in conjunction with the pollen record (Whitlock et al. 2008). On the Olympic Peninsula, many patterns in vegetation can be traced to a history of fire, suggesting an important interaction of fire and climate. Second, current biodiversity hotspots suggest the long-term maintenance of species diversity in these areas. Mountain regions may maintain biodiversity by providing "safe sites" of favorable conditions (refugia) where components of diversity can retreat during unfavorable periods and subsequently expand (Keppel et al. 2012). The modern biogeography of the Olympic Peninsula suggests these mountains were an important refugium south of the ice sheet during the glaciation. Third, the paleoecological approach is especially suited for long-lived organisms. For example, tree species that typically reach reproductive sizes only after 50 years and remain fertile for 300 years, such as many on the Olympic Peninsula, will have experienced only 30–200 generations since colonizing a location after Holocene warming about 11,000 years ago. By summarizing community change through multiple generations and natural disturbance events, paleoecological studies can examine the resilience of ecosystems to disturbances in the past, showing how many ecosystems recover quickly while others may not (Willis et al. 2010).

Interpreting ecological communities and ecosystems from fossil records presents a set of methodological challenges that have been recently addressed with considerable success. Overall, retrospective studies are very labor intensive and knowledge is accumulated in steps, with detailed studies of information-rich sites providing the largest gains. The Olympic Peninsula has no shortage of important paleoecological studies (especially paleovegetation from pollen records) and is nested in a region that has several robust paleoclimate reconstructions.

Aims

This book brings together decades of research on the modern natural environment and paleoenvironmental change since the Late Pleistocene of the Olympic Peninsula. Part 1 presents the modern environment and biogeography of the Olympic Peninsula. Rather than simply reviewing previous studies, we take advantage of a multitude of data sources to portray the gradients of climate, vegetation, and disturbance regimes on the peninsula. Inspired by atlases produced at the University of Oregon (Loy et al. 2001; Marcus et al. 2012), we extensively display primary data in maps and graphics whenever it effectively supplements a point in the text. In Chapter 1, the current climate gradients on the Peninsula and recent trends in climate over the past 100 years demonstrate how climate change is beginning to accelerate on the peninsula. The vegetation of the peninsula is described with respect to five major forest zones and their association with climatic gradients. Lastly, the natural disturbance regime, which is strongly influenced by climate, is reviewed, including fire, wind, insects, and geomorphic disturbances. Chapter 2 presents the geological history and the historical development of biodiversity on the Olympic Peninsula. The long-term geologic history, beginning in the middle Cenozoic, sets the stage for the origin of the Olympic Mountains. What climate changes accompanied the development of the Olympic Mountains during the past 30 million years? How did this region become dominated by some of the largest conifer species in the world? Patterns of endemism and species disjunction are also presented.

In Part 2, we provide temporal depth to the patterns described in the first section. We review the original paleoecological studies from the Pacific Northwest and then turn our focus onto our paleoecological records of changing forest composition and fire over the last 14,500 years. Motivated by pioneering work in addressing ecological questions from the paleovegetation record (Delcourt and Delcourt 1991), we tackle a broad array of ecological questions of the mechanisms underlying the changes in forest communities over space and time. The last 14,500 years begin with the first major warming at the end of the Last Glacial Maximum and the retreat of the continental ice sheet. This period is easily studied due to the abundance of geologic records from lake sediment, ocean sediment, and soil. Over this interval there have been abrupt climate changes, rapid changes in forest composition, and large shifts in fire regimes. Several tree species made their first appearance several millennia after the ice sheet retreated, while others may have been present in small refugia close to the ice-sheet margin, expanding about 13,000 years ago. Tree species that are associated with specific elevations today have shifted their distributions up or down due to changing climate, but sometimes in unexpected ways. The frequency of fire, currently a minor component of the disturbance regime on the Olympic Peninsula, was at times much greater than it is today. Chapter 3 presents the history of postglacial paleoclimate change on the Olympic Peninsula. Various records of past climate are synthesized, including the record of glaciation from the Last Glacial Maximum (21,000 years ago) to the present. Chapter 4 presents the postglacial vegetation history of the biota as determined from a set of pollen records, with five recently developed records receive particular focus. Various means of data synthesis (for example, mapping paleoecological data and modern pollen analog methods) demonstrate changing vegetation patterns. This part of the analysis includes a review of over 30 paleoecological records from western Washington and southwest British Columbia. Chapter 5 presents a brief review of important archeological sites and places their occurrence in time and space in the context of the environmental changes occurring on the peninsula. Lastly, Chapter 6 presents several areas of knowledge gaps and additional needed research.

This book does not explicitly address impacts of ongoing and projected climate changes on the peninsula. There are several assessments related to this topic (Jenkins et al. 2002; Halofsky et al. 2011; Devine et al. 2012). However, the data presented here are relevant to understanding the mechanisms governing ecological change and historical precedents of the modern changing environment on the Olympic Peninsula.

Springer

http://www.springer.com/978-3-319-11013-4

Late Pleistocene and Holocene Environmental Change
on the Olympic Peninsula, Washington
Gavin, D.G.; Brubaker, L.B.
2015, XII, 142 p. 52 illus., 36 illus. in color., Hardcover
ISBN: 978-3-319-11013-4