

## **Alpine Treelines: Functional Ecology of the Global High Elevation Tree Limits**

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## Book Reviews

ALPINE TREELINES: FUNCTIONAL ECOLOGY OF THE GLOBAL HIGH ELEVATION TREE LIMITS. By Christian Körner. Basel: Springer, 2012. 220 pp. \$89.95 (hardcover). ISBN: 978-3-034-80395-3.

Christian Körner has been at the forefront of research investigating treelines, and in the late 1990s and early 2000s he proposed a unifying theory to explain the global occurrence of this high-elevation phenomenon (Körner, 1998, 1999, 2005, 2007). Since the early publication of this work, he has collaborated with others to refine the theory and to gather additional data to support his view of why treelines occur. This book is a culmination of that line of thought and lays out his ideas in a clear fashion that is richly illustrated and adequately referenced. The book provides Körner an opportunity to lay out his ideas in detail. For the reader it is a trip through both contemporary and historic literature on treelines that exhaustively evaluates both Körner's thinking about the causes of treeline and a suite of alternative hypotheses for which he finds little support to explain the global treeline phenomenon.

The crux of Körner's hypothesis is that when treelines are considered globally, they closely follow the 6.4 °C average annual temperature isotherm. Körner stressed that when we consider the distribution of upright trees in contrast to seedlings and stunted tree growth forms such as *krummholz* there is remarkable consistency among treeline position around the globe. The mechanism for the global treeline isotherm approach is that upright full-sized trees are more closely coupled aerodynamically with the atmosphere than are seedlings and short-statured vegetation types common above the treeline. Körner's ultimate conclusion is that the mean growing season temperature plays a central role in determining treeline position and in influencing the mechanisms that translate temperature into a life-form boundary.

One outcome of this conclusion is that the position of treeline should not be viewed or measured in elevation, but rather should be considered in relation to specific thermal conditions on a mountainside (i.e. the global treeline isotherm). When treeline is viewed this way the variability of undisturbed treelines from scales that range from the hillslope to the global are more easily understood. The correlation of treeline with a relatively easily mapped physical phenomenon allows Körner to propose that alpine treeline can serve as a global bioclimatic reference line against which other bioclimatic zones can be compared.

Körner has previously stressed the importance of defining the treeline (Körner, 2007). He commendably proposes a single definition of treeline in this book, and adheres to it throughout the monograph. His definition is based on the tree life form rather than a tree species. In this context, trees are upright woody plants with a dominant stem that reaches a height of at least 3 m. Treeline is then defined as a line that connects groups of trees at their uppermost limit on a mountain slope. Treeline is rarely contiguous and forms a zone on the mountainside that may be interrupted by a variety of environmental conditions and processes ranging from

human activity to substrate availability. Because Körner is interested in climatic treelines, he draws a distinction among sites that are true treelines and those that are merely a tree species limit. If non-native trees are capable of surviving above the local treeline, but do not due to a biogeographic happenstance, Körner does not consider the treeline to be a true climatic one. He therefore discounts its importance from the standpoint of his global theory. Although Körner notes that these cases are uncommon (e.g. the Hawaiian Islands, and *Nothofagus* treelines in New Zealand), some treeline scientists will find this problematic.

After laying the groundwork for his global view of treelines in the early chapters of this book, Körner presents details of the data that support his hypothesis. Alternative hypotheses are considered, and Körner explicitly addresses the influences of reproduction, stress, and nutrient status on the growth and survival of trees at high elevations. He concludes with an overview of the information that he has painstakingly laid out in the first 11 chapters of the book and then places his theory into a temporal perspective by considering what his thoughts mean for treelines in the recent and distant past and what his understanding of treeline may mean for future treelines.

The final chapter addresses the question of whether treeline is in equilibrium with climate, and, if so, at what temporal scale this equilibrium develops. Körner surveys the literature for evidence in the recent and distant past to address this question. He finds that in the recent past (<200 years) treeline does not seem to be in equilibrium with climate changes. The climate has changed too rapidly to allow for adult trees to track with the climate. Körner assumes a lag time of greater than 50 years between climate change and the equilibration of the treeline. This is due to factors including the length of time that it takes for a seedling to grow to "tree-size," and the frequency of adequate seed production. In contrast to the short-term disequilibrium between climate and treeline position, Körner notes that when viewed over longer periods using a variety of paleoecological proxy data, that treeline position is tracking temperatures consistent with what we observe today. Körner's treatment of the historical data on treeline change is not exhaustive, but is sufficient to illustrate his main point.

One of the great strengths of the approach that Körner takes in this book is the focus on treelines globally. Even without the emphasis on a global treeline driver, the inclusion of data from so many different treeline sites outside of the northern temperate zone is refreshing. There is comparatively little treeline research published from the tropics and it is nice to see so much of that work referenced in one volume.

Although Körner provides a wealth of data in support of his hypothesis, he will have critics. Körner's concentration on treeline as a global phenomenon disregards the impact of local conditions that may influence the pattern and position of treeline. He acknowledges that specific disturbance types such as herbivory, fire, wind, and human activity can have local influences on the tree survival and treeline position, but these are not the emphasis of his monograph. For those readers interested in detailed discussions of processes that lead to fine-scale heterogeneity at treelines, other sources will offer a much greater depth of discussion. The coarser scale explanations of a phenomenon, however, are worth consider-

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ing. Readers familiar with hierarchy theory (Allen and Starr, 1982) will easily find a way to situate fine-scale questions within the coarse-scale controls laid out here by Körner.

There are several other books that have been published previously on treeline. Körner acknowledges this, and it is useful to know how his work fits into the collection of pre-existing treeline monographs. Earlier volumes have been either aimed at a different kind of audience (Arno and Hammerly, 1984), are location-specific (Butler et al., 2009), or focus on scales below the global (Holtmeier, 2003). This volume is most closely related to Tranquillini's (1979) *ALPINE TIMBERLINE*, and in many ways reads as an update on the status of physiological ecological research at treeline, but with an emphasis on the global treeline.

Overall this is an excellent addition to the library of anyone interested in the functional ecology of trees at high elevations. Graduate students and those new to studying treeline should be encouraged to read the text, and those of us who have been interested in treeline research for a long time will undoubtedly find something new in this book.

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THE REINDEER BOTANIST: ALF ERLING PORSILD, 1901–1977. By Wendy Dathan. Calgary: University of Calgary Press co-published with the Arctic Institute of North America, 2012. 726 pp. \$46.95 (softcover). ISBN: 978-1552385869.

In this book we learn of Erling Porsild, who he was, his path from being a very young Danish botanist in Greenland to respected

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authority on arctic botany in Ottawa. First, I must say this is a terrific biography. Wendy Dathan has given us Erling's life as gleaned from a mountain of material: notebooks, interviews, library searches, archives, and correspondence of Erling to and from others (family, colleagues, administrators) all of which are part of the narrative.

As a taxonomist, in Alaska, I have made frequent use of Erling's "Contributions to the flora of Alaska," and so I was aware of the extraordinary trek made by him and his brother Bob, from Seward, Alaska, into the Interior, out to the coast at Unalakleet and Pastolik, and finally northward. After a side trip to Little Diomedea, then from Barrow across Alaska to Canada, the brothers made their way south following the Mackenzie River to the railhead and home to Ottawa.

The brothers had been hired by the Canadian government to learn all they could about reindeer husbandry from what was then deemed to be the successful Alaskan experience. Then they were directed to assess the suitability of the route proposed for a reindeer drive from Alaska to Kittigazuit on the east side of the Mackenzie River delta where the Canadian government planned to establish reindeer herds as a means to alleviate periodic famine among the Eskimo when caribou were not available. Ironically, the Alaskan reindeer industry was about to go into decline and then near-collapse. Nevertheless, reindeer herding survived and persists to this day, mainly on the Seward Peninsula.

I was aware of the broad-brush strokes of their journey, but the details have been limited to short articles by Erling and others, particularly ones in journals not among those I usually see. A government document Erling wrote in 1929 was in language so typically spare and understated that we learn from it very little of what actually happened. In *THE REINDEER BOTANIST* we get all of the fascinating details. We learn about the trek, the reindeer drive, and an analysis of the aftermath. Success and failure of the project is dissected, and, as is pointed out, the people who were suffering most from famine lived farther to the east where the vegetation would not support reindeer herding. The government was left with the initial objectives unfulfilled.

Accounts of the reindeer drive itself from the perspective of those doing the driving are not part of this biography, since Erling had nothing to do with the drive per se until the reindeer approached the delta. However, George Scotter (1978, 1982) wrote of Andrew Bahr, the herder in charge, and the five years (63 months) of struggle under exceedingly difficult conditions. From his account the journey could well be described as two feet forward, one foot back. Herding cats might have been easier.

Of course, the biography deals with more than the reindeer work, although it is a major element. Wendy begins with background from Erling's earliest days growing up on Disko Island on the southwest coast of Greenland with brother Bob. Their father, Morton Porsild, was a distinguished botanist and founder of the arctic research station where the family lived for decades. Wendy follows Erling through all the ups and downs of his life, his loves and tragic losses, and his professional uncertainties while he tried to chart a course to a permanent position as botanist at the National Museum of Canada. In the end, Erling succeeded and did indeed become the chief botanist. He was determined and decisive, yet quiet and reserved.