Correspondence

Response

I thank these authors (Buma et al., 2014), for their interest in my paper. The topic of postglacial tree migration has always been a controversial one, so it is not surprising that my review of the evidence for the postglacial establishment of Pacific Northwest forest species in southern Alaska would generate some additional controversy. Burma et al. are perfectly correct in their statement that I did not consider localized refugia for these tree species within southeast Alaska during the LGM. However, I take exception to their statement that I did not consider the ecology of these trees in my reconstruction of regional events during the last glacial maximum (LGM). On the contrary, a consideration of the ecological requirements of these PNW tree species is precisely the reason I excluded them from consideration in refugia? In refugia?

I was aware of the work of my colleagues, Paul Carrara and Tom Ager (USGS, Denver) in southeast Alaska, and I have no argument with their conclusions about the likelihood of ice-free regions on some of the islands of the Alexander Archipelago and adjacent continental shelf regions. I should have stated this in my article. I also heartily agree with their statement (Carrara et al., 2007), ‘Exposed, unglaciated land does not necessarily equate to viable populations of flora and fauna.’ Having made that statement, they immediately go on to defend the idea that unglaciated patches of southeastern Alaska did provide suitable habitats for the regional biota. This concept is at the heart of Buma et al.’s argument. However, even if parts of the Alexander Archipelago remained ice-free during the last glaciation, would these periglacial regions have provided suitable habitat for PNW trees? Since we have no suitable proxy evidence from these hypothesized refugia, how can we tell what the conditions were like there during the LGM: the climatic bottleneck through which all high latitude biota had to pass, if they survived in situ in refugia?

Carrara et al. (2007) carried out an extensive survey of the Quaternary geology of the Alexander Archipelago, searching for regions that were ice-free during the LGM. While they did find a lack of evidence for glaciation on parts of six islands and adjacent continental shelf regions, they apparently also failed to find even a single pond, lake or bog with a basal age predating the end of the last glaciation in southeast Alaska. I would gladly accept the authors’ hypothesis about the existence of a glacial refugium for PNW forest in southeast Alaska, if the following conditions were met: (1) If one or more sedimentary archives (pond, lake or bog) are found in the potential refugial regions that have undisturbed basal sediments yielding a 14C age greater than 13,000 14C yr BP; (2) if those glacial-age sediments were found to yield pollen and plant macrofossil remains of PNW forest species. If these two conditions were met, then we could say definitively that this region formed a glacial

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What degree of ice-proximal cooling affected any exposed land on the Alexander Archipelago during the LGM? A 30-year study of temperature and precipitation at an ice-proximal site adjacent to Wolverine Glacier, about 40 km northeast of Seward, Alaska, showed that summer air temperatures near the ice margin are about 4.5 °C cooler than those at Seward (adjusted for elevation by a lapse rate of 0.2 °C per 100 m), and mean January temperatures were 3 °C cooler (USGS, 2014). The modern mean July temperature (TMAX) in the Alexander Archipelago region (based on data from Port Alexander: NOAA, 2002) is about 13 °C. Modern mean January temperature (TMIN) is 1 °C. We have no paleoclimate reconstructions for the last glacial maximum interval in southeast Alaska, precisely because of the lack of fossil sites from this interval. Insect fossil evidence from interior Alaska (Elias, 2000) suggests that mean July temperatures were about 4 °C cooler than today at sites that were well away from the chilling effects of glacial ice, and mean January temperatures were about 8 °C cooler. Taken in combination, LGM temperatures in southeast Alaska were considerably cooler than modern, being depressed by a combination of cold LGM climates in the northern high latitudes and the influence of local climatic cooling due to proximity to glacial ice. As a crude estimate, then, we might infer that mean July temperatures on any unglaciated landscapes on the Alexander Archipelago were as much as 8.5 °C cooler than modern values, and mean January temperatures were about 11 °C cooler than today. Using this estimate of LGM regional cooling, we arrive at a mean July temperature of 4.5 °C and a mean January temperature of −10 °C. This summer temperature estimate is well below the known thermal tolerances of PNW forest tree species (Table 1). The six main PNW tree species of southeast Alaska all require TMAX values of at least 7.5 °C, and two of them require TMAX values of 10 °C or more (Thompson et al., 2006). The estimated TMIN value of −10 °C is too cold for both shore pine and Nootka cypress (Table 1).

In summary, I did not consider that PNW forest tree species persisted in southeast Alaska through the last glaciation for two main reasons: (1) There is no fossil evidence (i.e., pollen, plant macrofossils or stomata) for the presence of these trees during the last glaciation; (2) Our best estimates of LGM climatic conditions for ice-proximal sites in this region indicate that summer temperatures were simply too cold to support the growth and reproduction of these tree species. So until we have the fossil evidence to test Buma et al.'s assertions about an LGM refugium for PNW tree species in southeastern Alaska, this particular kind of refugium seems quite unlikely.

Table 1

<table>
<thead>
<tr>
<th>Species</th>
<th>TMAX range (°C)</th>
<th>TMIN range (°C)</th>
<th>MAP range (mm/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitka spruce</td>
<td>8–20</td>
<td>−15 to 3</td>
<td>900–5000</td>
</tr>
<tr>
<td>Western hemlock</td>
<td>7.5–19</td>
<td>−11 to 3</td>
<td>800–5000</td>
</tr>
<tr>
<td>Mountain hemlock</td>
<td>7.5–22</td>
<td>−13 to 3</td>
<td>700–6000</td>
</tr>
<tr>
<td>Shore pine</td>
<td>10.5–15</td>
<td>−8 to 3</td>
<td>1000–5000</td>
</tr>
<tr>
<td>Nootka cypress</td>
<td>10–14</td>
<td>−7 to 3</td>
<td>1500–6000</td>
</tr>
</tbody>
</table>

References


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