Climate refuges and disappearing climates in the protected areas of North America

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Lawler et al. 2013
Images courtesy of the Department of Geological Sciences at Brown University, the National Center for Ecological Analysis and Synthesis, and the Department of Geography at the University of Oregon.
Climatic Velocity

How far will species need to move to track changing climates?

Locations with low climatic velocity are considered refugia

Carroll et al. 2015 and 2017
Refugia are locations with climatic conditions that are less prevalent regionally then they were historically
Defining Climate Analogs

Lower Tolerance for Change

Higher Tolerance For Change

0.9

1.5
Bowman et al. 2002, Sutherland et al. 2000, Smith and Green 2005
• Business as usual emissions (RCP 8.5)

• 3 GCMs (CMIP5 - INM CM4, MIROC5, GFDL CM3)

• 2 Time Periods (2050s, 2080s)

• IUCN I-VI Protected Areas (WDPA)

Resolution – 1km

Macrorefugia
Refugia and Protected Areas

- Protected areas disproportionately cover refugia relative to their coverage of the general landscape.

- ~30% of protected areas include some refugia

- ~75% of refugia are not currently protected
Disappearing Climatic Conditions

Proportion of Land Area

Latitude

Proportion of Land Area
2080s

Low tolerance for climate change
Weak dispersal capacity (0.5 km)

High tolerance for climate change
Weak dispersal capacity (0.5 km)
2080s

Low tolerance for climate change

Weak dispersal capacity (0.5 km)

Low tolerance for climate change

Strong dispersal capacity (10 km)
Percentage of protected areas affected by disappearing climates by the 2080s

<table>
<thead>
<tr>
<th>Model</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>INM CM4</td>
<td>31%</td>
</tr>
<tr>
<td>MIROC5</td>
<td>75%</td>
</tr>
<tr>
<td>GFDL CM3</td>
<td>88%</td>
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</tbody>
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Implications

• Refugia are accessible in mountainous regions, but contract over time making these refugia temporary and area limited.

• Adaptation in low elevation, flat areas requires either strong dispersal capabilities or low climate sensitivity. Not area limited.

• Does not account for vegetation and other habitat needs, microrefugia, or barriers to dispersal.
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More information and data available on http://adaptwest.databasin.org