Plant Endemism, Climatic Refugia and Climate Change in Rainforests of Subtropical Australia

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Patterns of Rainforest Plant Endemism Relate to Stable Mesic Refugia and Species Dispersal Limitations - Paper accepted (with changes Feb 2012) J Biogeography

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Refugia and endemism are biogeographical concepts important for climate change adaptation. Refugia correspond to centres of endemism where areas retain past climates and/or exhibit features that buffer species from climatic change. Aridification of Australia since the Eocene has resulted in contraction of once dominant rainforests to <1% of land area. Despite their small extent, Australian rainforests retain high diversity and endemism. Here we address knowledge gaps relating to endemism and persistence of subtropical Australian rainforest flora to identify regions that may have been refugia for rainforest biota. We mapped 179 endemic rainforest plants to identify concentrations of endemic taxa and small range endemics. We then test whether centres of endemism coincide with other features indicating refugia (high habitat stability over 120,000 years and concentrations of less dispersable taxa). We identified five main centres of endemism including all but one endemic taxa. Historical stability and contemporary processes affecting diversity (rainfall, area, and topographic variation) together explained 58% of variation in plant weighted endemism. The refugial function of these regions is further supported by evidence that poorly dispersed taxa are concentrated in stable habitats. Conservation efforts aimed at reducing existing threats to refugia could promote persistence of taxa including under future climates. Vegetation clearing has reduced the extent of two major refugia (Sunshine Coast and Border Ranges) by 66%, where currently 48% and 31% of remaining rainforest and four endemic taxa are

outside conservation reserves. Targeted protection and restoration of refugia should be a priority to conserve rainforest biodiversity in subtropical Australia.

Climate change adaptation

The stable mesic refugia identified here have sheltered ancient gondwanan rainforest taxa during increasing aridity (Byrne *et al.* 2011). Anthropogenic climate change could cause extinctions of vulnerable species including those confined to summits (Hughes 2003; Williams *et al.* 2003). However complex topography can increase rainfall and reduce climate change velocity, promoting persistence of endemic and less dispersable species (Sandel *et al.* 2011). While refugia are likely to shelter species, increasing climate change may overwhelm smaller, less topographically varied refugia such as Bulburin and the Sunshine Coast (Loarie *et al.* 2009). Endemic taxa in these refugia may find suitable habitat in three higher latitude and altitude refugia if they could desperse across dry barriers. However less dispersable taxa may not migrate fast enough (Loarie *et al.* 2009; Sandel *et al.* 2011).

Targeted restoration of refugia could increase climate change resilience by reducing existing threats, restoring under-canopy microclimate, increasing connectivity, and ecological function (Kanowski *et al.* 2008; Shoo *et al.* 2011). When conserving and restoring rainforest, an adaptive management approach (Hannah *et al.* 2002) should include identifying and monitoring vulnerable species (Williams *et al.* 2008). If monitoring indicates vulnerable species decline, advanced propagation methods are available (Ashmore *et al.* 2011) and translocation should be considered to avert extinction (Hoegh-Guldberg *et al.* 2008). Optimal timing can reduce translocation cost and increase success rates (McDonald-Madden *et al.* 2011). By identifying refugia for subtropical Australian rainforests we have addressed a key knowledge gap for conservation planning and climate change adaptation (Steffen 2009). Human actions continue to change Earth's climate and conservation of these ancient forests is now also in our hands.