Does the middle Eocene Río Pichileufú flora from Patagonia, Argentina record initial floristic response to global cooling and South American Isolation?

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Introduction

Southern Hemisphere fossil plants indicate a rainforest biome across much of Late Cretaceous and Early Paleogene Gondwana, but global cooling and separation of South America and Australia from Antarctica are linked to significant ecological change in the middle Eocene through the Oligocene. **The Río Pichileufú fossil flora (RP) from Río Negro Province, Argentina (Fig. 1) offers an exceptional opportunity to observe the earliest signals of ecological change in middle Eocene Patagonia.** The principal record of Patagonian fossil plants during the Early Eocene Climatic Optimum (EECO) is the Laguna del Hunco fossil flora (LH) in Chubut Province, Argentina dated 52.22 (±0.22) Ma (Wilf, 2012). RP is dated ca. 3 Ma after the EECO at 47.74 ±0.05 Ma (Wilf 2012), during the very first stages of cooling and separation of South America from Antarctica (Fig 2). Although the 1938 E.W. Berry RP monograph still represents the most diverse described Cenozoic fossil flora from South America, it provides only a qualitative account of the assemblage and just a fraction of its specimens have received modern paleobotanical treatment. A comprehensive update of the RP assemblage combined with quantitative data from recent unbiased collections will provide the data needed to compare RP with LH and test for signals of floral response to cooling in Patagonia and South American biogeographic isolation.

Objectives

To prepare for quantitative tests of paleofloral response to cooling and biogeographic change, I begin with an update of the RP flora. RP diversity will be estimated using morphotypes and systematic comparisons with type material to improve our understanding of floral composition.

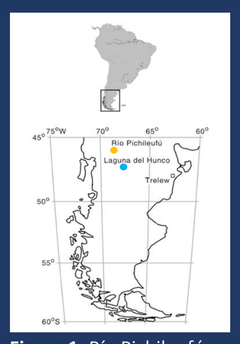


Figure 1. Río Pichileufú and Laguna del Hunco locations mapped onto 50 Ma positions of modern coastline. Figure adapted from Wilf et al., 2005.

Materials

- 400+ RP specimens from the EW Berry 1938 Type and Cohort collection at the Smithsonian National Museum of Natural History
- 1200+ RP specimens from the unbiased 2002 and 2005 collections at the Museo Paleontólogico Bariloche (Bariloche, Argentina)
- 4300+ LH specimens in the recently published collection at the Museo Paleontológico Egidio Feruglio (Trelew, Argentina)
- All collections quarried from tuffaceous caldera-lake sediments of Huitrera Formation indicating similar paleoenvironments

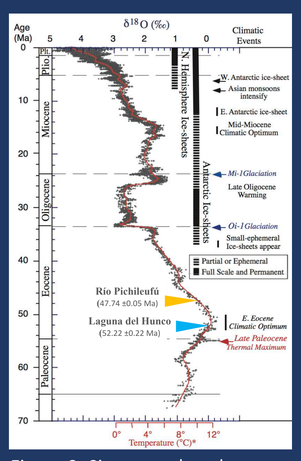


Figure 2. Site ages placed on global deep-sea oxygen isotope records adapted from Zachos et al., 2001.

Río Pichileufú Leaf Database

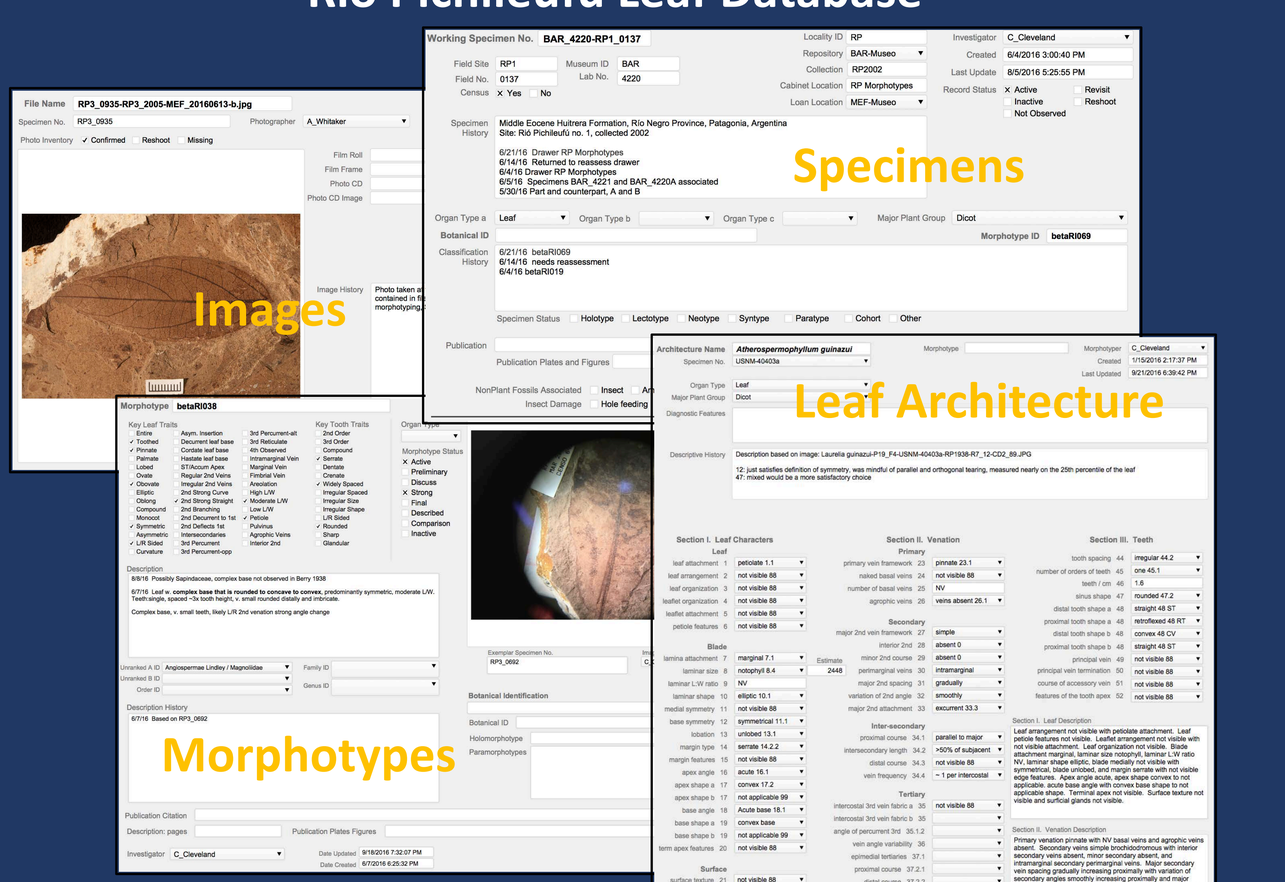


Figure 3. A project database, developed using FileMaker Pro Advanced v. 14.0.4, organizes leaf data in a relational framework and generates automated descriptions to assist manuscript preparation. Terminology from the *Manual of Leaf Architecture*, 2009 (Ellis et al., 2009) is used to ensure consistent trait comparisons.

Sample of Leaf Diversity

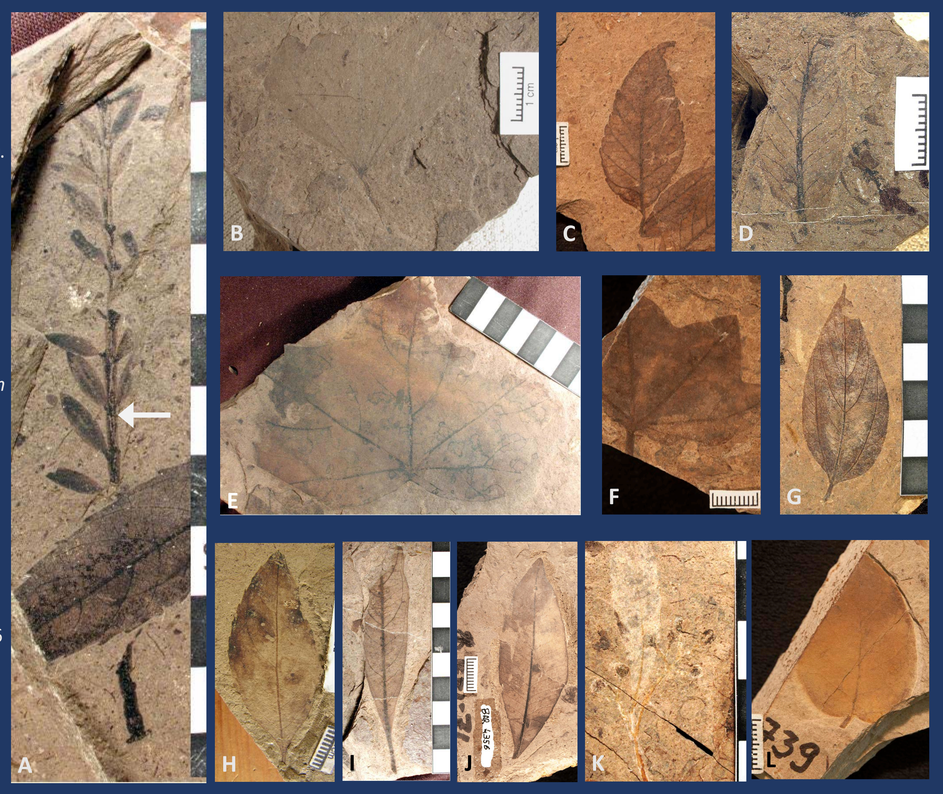
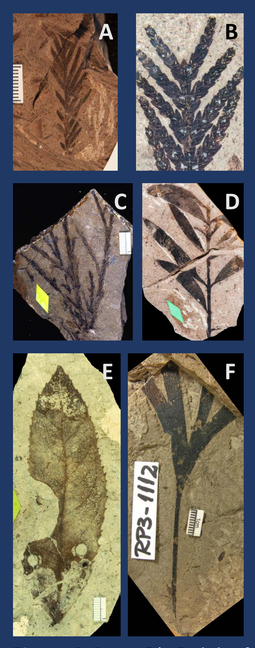


Figure 5. A sampling of floral diversity and preliminary identifications from the Río Pichileufú collections (Preliminary identification, Morphotype No., Specimen No.).

A. *Retrophyllum* sp., RI097, BAR_4705
B. Unidentified, RI086, BAR_4595
C. Unidentified, RI039, RP3_0827
D. Unidentified, RI073, BAR_4639
E. *Cochlospermum previtifolium* Berry, RI071, RP3_0942
F. Unidentified, RI071, RP3_0942
G. *"Banera" prehernandiensis* Berry, RI082, BAR_4622
H. *"Villaresia" congonhifolia* Berry, RI080, RP3_1111
I. *"Nectandra" prolifica* Berry, RI048, BAR_4450
J. Myrtaceae, RI012, BAR_4356
K. Myrtaceae with infructescences attached, RI087, BAR_4706
L. Fabaceae, RI052, RP3_0739

Floral Change in Eocene Patagonia



Berry (1938) originally assigned the RP flora to a Miocene age and highlighted its affinities to both extant South American and Australasian floras. In contrast, recent $^{40}Ar/^{39}Ar$ dates show that the flora is earliest middle Eocene (Wilf, 2012), and systematic revisions of angiosperms and conifers (Fig. 4) have greatly strengthened Australasian links. Several of the conifer taxa, such as *Papuacedrus* and *Dacrycarpus,* provide evidence supporting a humid and everwet environment with links to extant West Pacific montane forests (Wilf et al., 2009; Wilf, 2012). The flower of basal Asteraceae *Raiguenrayun cura* from another Río Pichileufú locality (Barreda et al., 2010; Barreda et al., 2012) represents a paleobiogeographic link between South America and Africa (Bandoni De Oliveira et al., 2009). Insights from a well-developed understanding of RP and its comparison with LH will be used to investigate transition from Ancient Gondwanan to extant-South American affinities and test the proposed paleogeographic explanations.

Figure 4. Some Río Pichileufú taxa that have been revised since Berry's 1938 monograph. **A.** *Acmopyle engelhardti* (Berry) Florin 1940; specimen RP3_1068. **B.** *Papuacedrus prechilensis* (Berry) Wilf et al. 2009; specimen BAR-4742a. **C.** *Dacrycarpus puertae* Wilf 2012; USNM-40381. **D.** *Agathis zamunerae* Wilf 2014; USNM-40378. **E.** *Atherospermophyllum guinazui* (Berry) CL Knight 2013; USNM-40403. **F.** *Ginkgoites patagonicus* Villar de Seoane et al. 2015; specimen RP3_1112.

Discussion

Previous work indicates that although many plant taxa are found at both RP and LH, including gymnosperms such as *Dacrycarpus* and *Agathis*, RP lacks taxa abundant at LH, including angiosperms *Eucalyptus* and *Gymnostoma*. Also, taxa observed at RP are not represented at LH, including Asteraceae flowers (Barreda et al., 2012). This work will provide the foundation for a comprehensive update of Berry's RP monograph and quantitative comparison of the RP and LH assemblages in the context of global cooling and South American biogeographic isolation. I predict net loss of ancient Gondwanan rainforest associations and net gain of clades with affinities to extant South America floras as well as shifts in relative abundance.

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