

# 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

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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.

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,

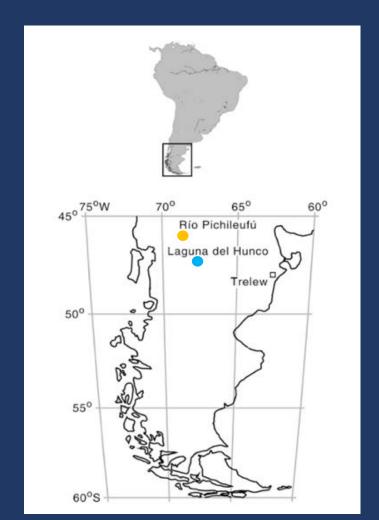
RP3\_0827 D. Unidentified, RI073,

BAR 4639

## Sample of Leaf Diversity

## Objectives

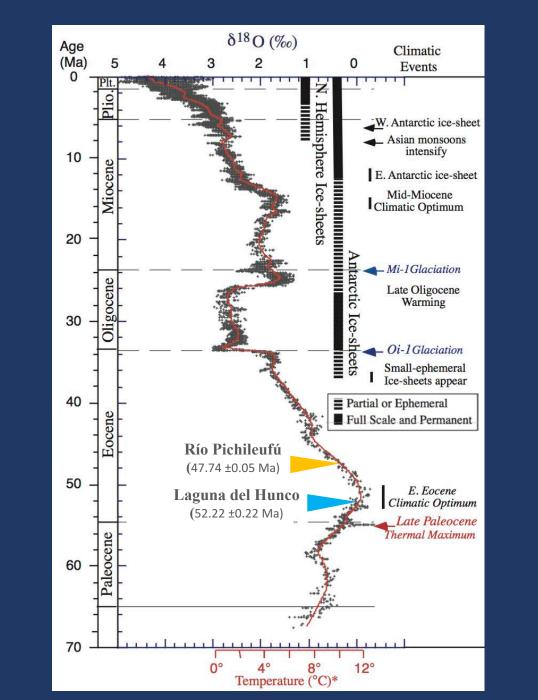
To prepare for quantitative tests of paleofloral response to cooling and biogeographic change, I begin with an update of the RP flora. RP diversity will be estimated using morphotypes and systematic comparisons with type material to improve our understanding of floral composition.



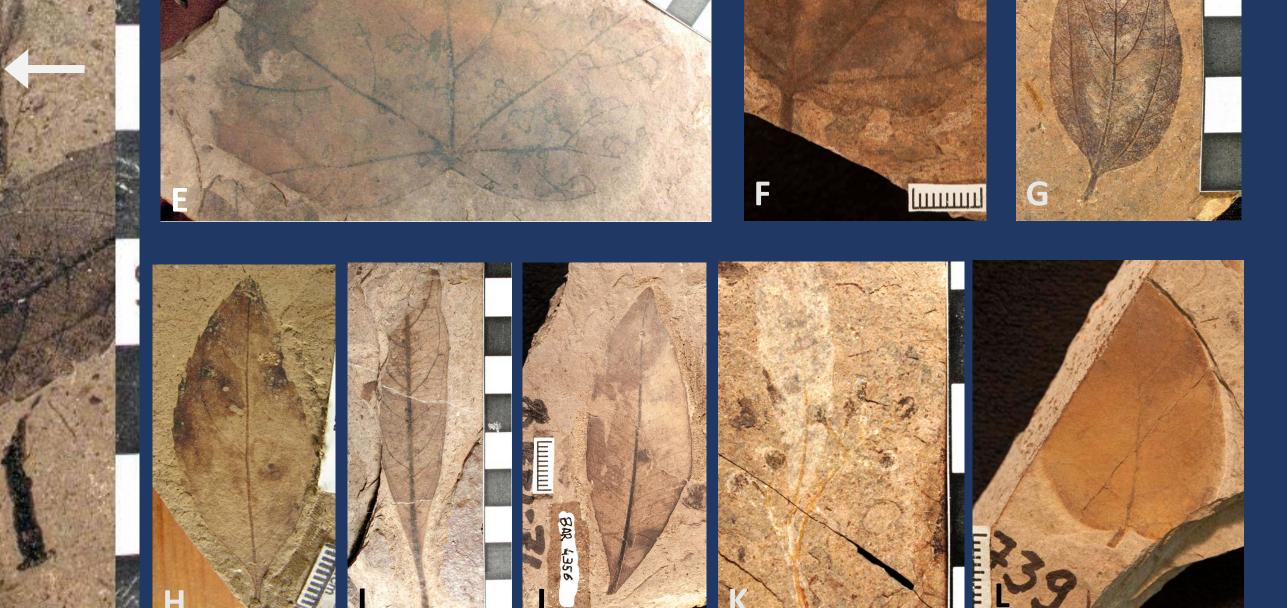
### Materials

 400+ RP specimens from the EW Berry 1938 Type and Cohort collection at the Smithsonian National Museum of Natural History

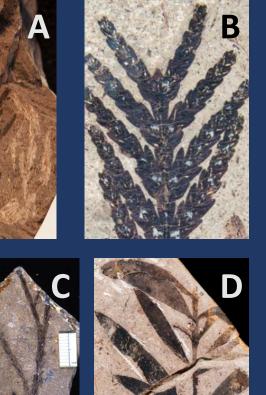
- 1200+ RP specimens from the unbiased 2002 and 2005 collections at the Museo Paleontólogico Bariloche (Bariloche, Argentina)
- 4300+ LH specimens in the recently published collection at



- *E. Cochlospermum previtifolium* Berry, RI071, RP3\_0942F. 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



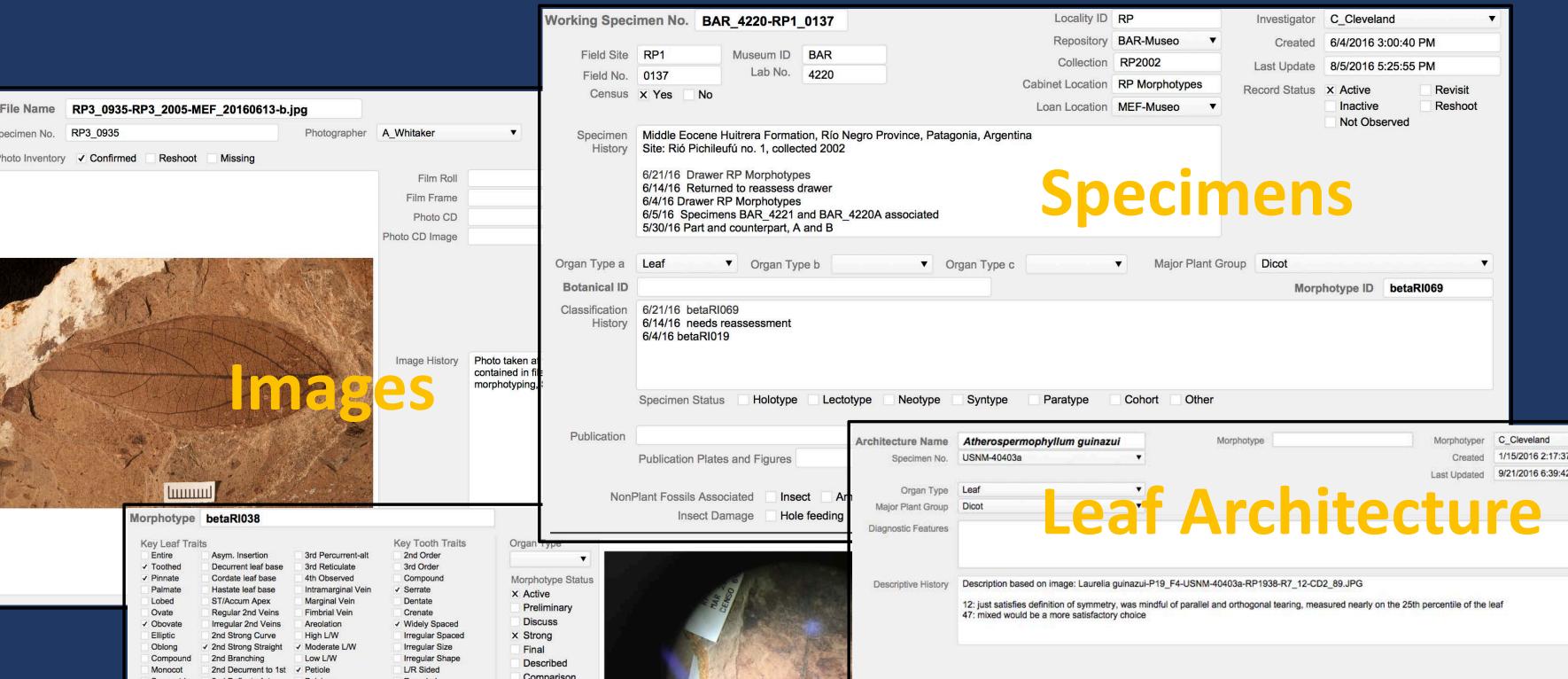
Berry (1938) originally assigned the RP flora to a Miocene age and highlighted its affinities to both extant South American and Australasian floras. In contrast, recent <sup>40</sup>Ar/<sup>39</sup>Ar dates show that the flora is earliest middle Eocene (Wilf, 2012), and systematic revisions of angiosperms 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 <u>Raiguenrayun cura</u> 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 1.** Río Pichileufú and Laguna del Hunco locations mapped onto 50 Ma positions of modern coastline. Figure adapted from Wilf et al., 2005. 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



surficial

**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\_112.

## 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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Publication Citation			base shape a 19	convex base
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**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.

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ex angle 16 acute 1 shape a 17 convex shape b 17 not app se angle 18 Acute b shape a 19 convex	e 16.1 V ex 17.2 V	distal course 34.3	not visible 88	۲	NV, laminar shape elliptic, blade me	edially not visible with	tio		
shape a 17 convex shape b 17 not app se angle 18 Acute b shape a 19 convex	ex 17.2 🔻			-					
shape a     17     convex       shape b     17     not app       se angle     18     Acute b       shape a     19     convex	The second second	Vent nequency of the	- I per interocerta.		symmetrical, blade unlobed, and margin serrate with not visible edge features. Apex angle acute, apex shape convex to not				
shape b17not appse angle18Acute bshape a19convex	oplicable 99 🔻				applicable. acute base angle with co	convex base shape to no	t		
se angle 18 Acute b shape a 19 convex	* * ·	Tertiary			applicable shape. Terminal apex no visible and surficial glands not visible	not visible. Surface textu			
shape a 19 convex	e base 18.1 🔻	intercostal 3rd vein fabric a 35	not visible 88	۳	VISIDIE and Sumolar glands not not	JIE.			
	ex base 🔻	intercostal 3rd vein fabric b 35		۲					
shape b 19 not app	pplicable 99 🔻	angle of percurrent 3rd 35.1.2		•	Section II. Venation Description				
	isible 88 V	vein angle variability 36		۲	Primary venation pinnate with NV ba absent. Secondary veins simple bro				
Course 20		epimedial tertiaries 37.1		•	secondary veins absent, minor seco	ondary absent, and			
Surface		proximal course 37.2.1		•	intramarginal secondary perimargina vein spacing gradually increasing pr	proximally with variation of	of		
e texture 21 not visit	isible 88 🔻	distal course 37.2.2		¥	secondary angles smoothly increasi	sing proximally and majo	r		
I glands 22 not visit	isible 88 🔹 🔻	exterior 3rd course 38		¥	<ul> <li>attachment excurrent. Intersecondary proximal course parall major secondaries, length &gt;50% of subjacent secondary, dist</li> </ul>				
					course not visible, and frequency ~ Intercostal tertiary vein fabric not vis	1 per intercostal area.			
		Quaternary		4	percurrent tertiary veins and vein ar	angle variability . Epimed	lial		
		quaternary vein fabric 39		•	tertiaries with proximal course and tertiary course is . Quaternary vein				
		Quinternary			fabric , , and with . Marginal ultimat				
		quinternary vein fabric 40		•					
		areolation 41		•					
		FEV branching 42.1		•	Section III. Teeth Description				
		FEV termination 42.2		¥	Tooth spacing irregular with one orders of teeth and 1.6 teeth p cm. Sinus shape rounded and tooth shape straight/retroflexed convex/straight. Principle not visible and terminating not visible				
		marginal ultimate venation 43							

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