Catalog and Literature Guide for Cretaceous and Cenozoic Vascular Plants of the New world

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NULLIS IN VERBA (take no man's word for it)

Motto on the coat of arms of the Royal Society (London) granted by Charles II,

September 17, 1662

Notes: Most identifications above family level and tentative generic identifications (e.g., 'cf.' or 'type') are not included. Fl.= flora; Fm.= formation; Ma- million years; NLR= nearest living relative (see Mosbrugger, 1999; Mosbrugger & Utescher, 1997).

Among records of particular biogeographic interest, 1) Hansen et al. (2001) report pollen similar to regionally extinct taxa (including some Asian exotics) in deposits as young as 'after 2.8 Ma' (latest Pliocene) from Polk Co., FL: cf. Zamiaceae, cf. *Ginkgo*, cf. *Sciadopitys*, *Tsuga/Sciadopitys*, *Tsuga canadensis*-type, cf. *Tsuga mertensiana*, cf. *Dacrydium, Podocarpus, Pterocarya*, cf. *Engelhardtia* [*Alfaroa-Oreomunnea*], cf. *Zelkova* [*Ulmus/Zelkova*]. Some of these exotics (*Alangium, Engelhardia, Sciadopitys*) have been reported from the late middle to early late Miocene Bryn Mawr Formation along the mid-Atlantic Coast (head of Chesapeake Bay, MD; Pazzaglia et al., 1997). 2) Elsik (1974) reports pollen of *Nothofagus* from the Eocene of the Gulf Coastal Plain and elsewhere in North America.

A summary of the Late Cainozoic (Cenozoic) floras of Iceland is presented by Denk et al. (2011), Cenozoic palynofloras of Patagonia by Quattrocchio et al. (2013), and a study of the middle Miocene palynofloras of the Tehuacán Formation of Puebla, Mexico that includes a summary for other Cenozoic Mexican formations by Ramírez-Arriaga et al. (2014).

The composition used here for the middle Eocene (44 Ma) Clarno flora of OR (Manchester, 1994), and macrofossils of the latest Eocene (34.1 Ma) Florissant flora of CO (Manchester, 2001, table 1, and revisions and additions on pp. 141-147 to MacGinities's 1953 study) include further updates kindly provided by Steven Manchester (pers. comm., April, 2011). See also Retallack et al., 2000, appendices 7-11, Eocene-Oligocene, Clarno area, OR).

Radiometric dates for various sites within the John Day Formation, OR (late Eocene to early Oligocene) are 33.6-32.2 Ma (Bridge Creek flora, Meyer & Manchester, 1997, p. XV); about 38.8 Ma (lower part of the formation,Whitecap Knoll locality, Manchester, 2000, p. 51); and 36.2 Ma (near Post, OR, Manchester & McIntosh, 2007, p. 7).

A summary of late Paleocene to early Eocene floras, and middle Eocene to late Eocene and Oligocene floras in North America is provided by Pigg & DeVore (2010) and DeVore & Pigg (2010). A comparison of the palynomorphs and megafossils in the late Paleocene Almont flora of North Dakota is given in Zetter et al., 2011 (table 1). The composition used here for the middle Eocene Republic flora of Washington State was kindly provided by Kathleen Pigg (pers. comm., 2011; see also Pigg, DeVore, & Volkman, 2011).

Steffi Ickert-Bond (pers. comm., 2011) provided updates on the fossil record and molecular dating of divergences in *Ephedra*.

For a summary of the upland Eocene forests of western USA (mostly Idaho, also Montana, Nevada), at the generic level see Axelrod (1996). Several identifications, the suggested nearest living relatives (NLRs), and particularly the proposed associations often seem to conform to geoflora concepts; later revisons and studies indicate Cenozoic

vegetation did not move as such closely composed modern units. The identifications are now undergoing revision (Erwin & Schorn, 2005). For a review of western Eurasian-western North American, dry-adapted disjunct taxa (Madrean-Tethyan region) see Kadereit & Baldwin (2012: … "independent ecological shifts to dry environments and long-distance dispersal probably account for the majority of taxon-disjunctions studied; migration of lineages (pre)adapted to dry conditions across either the Beringian or the North Atlantic Land Bridges, much discussed in the literature, only rarely needs to be invoked" (p. 3). For other discussions of the history and biogeography of dry vegetation see references under *Pickeringia* (Fabaceae).

The influence of regional history on the angiosperm history of the Mexican lowland tropical forests is discussed by Magallón et al. (2014).

A revised list of plant taxa from the Neogene of Panama described by Berry (1918, 1921) and a summary of the palynological record in Panama for the past 20 million years is provided by Jaramillo et al., 2014 (tables 4, 6). A morphological-based system is used for naming the palynomorphs and suggested related genera are cited. The extant higher-level categories and families are: Bryophyta- Anthocerotaceae; ferns and allied groups- Adianthaceae, Blechnaceae, Cyatheaceae, Dryopteridaceae, Lycopodiaceae, Lygodiaceae, Marattiaceae, Ophioglossaceae, Polypodiaceae, Pteridaceae, Schizaeaceae, Selaginelliaceae; gymnosperms- Podocarpaceae; angiosperms-Acanthaceae, Amaranthaceae, Anacardiaceae, Annonaceae, Apocynaceae, Aquifoiaceae, Araceae, Arecaceae, Asteraceae, Betulaceae, Bignoniaceae, Bombacoideae, Boraaginaceae, Bromeliaceae, Burseraceae, Byttneroideae, Cacombaceae, Caesalpinioideae, Chloranthaceae, Clusiaceae, Combretaceae, Connaraceae, Cucurbitaceae, Cyperaceae,

Dilleniaceae, Dioscoreaceae, Ericaceae, Euphorbiaceae, Fabaceae, Faboideae, Fagaceae, Gentianaceae, Grewioideae, Juglandaceae, Labiatae, Lamiaceae, Lentibulariaceae, Loranthaceae, Malpighiaceae, Malvaceae/Malvoideae, Melastomataceae, Meliaceae, Mimosoideae, Myrtaceae, Nymphaeaceae, Ochnaceae, Onagraceae, Phyllanthaceae, Poaceae, Polygalaceae, Rhizophoraceae, Rubiaceae, Rutaceae, Salicaceae, Sapindaceae, Sapotaceae, Symplocaceae, Mimosoideae, Tetrameristaceae, Ulmaceae, Verbenaceae, Vochysiaceae.

For reference to the Guiana Shiled as an ancestral area see Givnish et al. (2011; for Bromeliaceae), Merckx et al. (2013; Gentianiaceae), and Givinish et al. (2004) and Janssen & Bremer (2004; Rapateaceae).

A summary of Early Cretaceous plant fossils from southern Patagonia is provided by Del Fueyo et al., 2007. See also Limarino et al., 2012; Archangelsky, Archangelsky, and Cladera, 2012.

Barreda and Palazzesi (2014, table 1) present a summary of the fossil palynomorphs from the Miocene Chenque and Puerto Madryn formations of Patagonia. A morphological-based system is used to name the fossils and they are referred to the following extant families with suggested generic afffinities. Bryophyta: Bartramiaceae, Riellaceae, Sphagnaceae; ferns and related groups: Azollaceae, Blechnaceae, Cyatheaceae, Dicksoniaceae, Gleicheniaceae, Hymenophyllaceae, Lycopodiaceae, Polypodiaceae, Pteridaceae, Schizaeaceae; gymnosperms: Araucariaceae, Cupressaceae, Ephedraceae, Podocarpaceae; angiosperms: Amaranthaceae, Anacardiaceae, Aquifoliaceae, Arecaceae, Bromeliaceae(?), Asteraceae, Cactaceae, Calyceraceae, Casuarinaceae, Celastraceae, Chloranthaceae, Convolvulaceae, Cyperaceae,

Ericaceae/Epacridaceae, Euphorbiaceae, Fabaceae, Goodeniaceae, Gunneraceae, Haloragaceae, Juncaceae(?), Liliaceae, Loranthaceae, Malvaceae, Malvaceae, Myrtaceae, Nothofagaceae, Onagraceae, Paracryphiaceae, Poaceae, Proteaceeae, Pologonaceae, Rosaceae, Rubiaceae, Salicaceae(?), Sapindaceae, Sparganiaceae, Symplocaceae, Thymeleaceae, Vivianiaceae, Winteraceae,

Poole et al. (2005; see also Cantrill & Nichols, 1996, Cantrill & Poole, 2005) are used here for cataloging the fossil plants, suggested affinities, geologic formations, and primary literature for the various Late Cretaceous (Conacian-Campanian) to middle Eocene floras of the Antarctic Peninsula (see also Cantrill & Poole,2012) .

For a note on "the known issues of estimating extinction rates from molecular phylogenetics based upon extant taxa in the absence of a complete fossil record (Rabosky, 2009, 2010; reviewed in Quental and Marshall, 2010," see D. E. Soltis et al., 2013 (Saxifragales).

An inclusive compilation intended to eventually include 'all angiosperm fossils and fossil sites globally from the Cenozoic' is the developing Cenozoic Angiosperm Database (http://paleodb.org/cgi-bin/bridge.pl) within the Paleobiology Database (http://paleodb.org). There is NESCent's (National Evolutionary Synthesis Center), The Fossil Calibration Database (A New Bioinformatic Tool for Dating Divergences of Extant Lineages by Synthesizing Paleontological and Molecular Data. Another focusing on fossil and recent pollen and spores is the PalDat- Palynological Database (http://www/paldat.org/; Buchner, R. & M. Weber 2000). There is the Paleobotany Project, Denver Museum of Nature and Science (http://www/paleobotanyproject.org/), Austrofossils for Austria and vicinity (http://www.oeaw.ac.at/austrofossil), and a

compendium index of North American Mesozoic and Cenozoic fossil plants at the Peabody Museum (http://peabody.research.yale.edu/pbci) . See also Wen et al. (2013, p.920- Integrative Biogeography Data Portal). A catalog of vegetation databases (21 treated in detail, 150 mentioned) is presented by Jürgen Dengler et al. (2012) at http://www/biodiversity-plants.de (see notice, Frontiers of Biogeography 2012, 4:4). There is a glossary of palynology by Peter Hoen on the University of Utrecht's website (http://www.bio.uu.nl/-palaeo/glossary/glos-int.thm) based on Punt et al. (2007). A world flora for extant plants is currently being developed (search: world flora online), the International Plant Names Index (IPNI) is a database of names and bibliographic information for extant vascular plants (www.ipni.org/index.html; Manchester 2009), and the Index Nominum Genericorum (ING) lists generic names for extant and fossil plants covered under the International Code of Botanical Nomenclature (Manchester 2009; see also Angiosperm Phylogeny Group (APG), 2016). Many electronic URL addresses and content change over time and some are discontinued. These can (perhaps better) be searched by author/date and key words.

For location of Estella Leopold's plant microfossils from Florisant, 'The collections are currently with me [University of Washington, Seattle] but will be placed with the USGS in Denver (Federal Center) in care of Keith McKinney, Curator [pers. comm., April 22, 2015].

Estrada-Ruiz et al. (2018) refer some late Cretaceous woods from the McRae Fm of south-central New Mexico to the Malpighiales, Myrtales, Oxalidales (*Mcraeoxylon waddellii*),and Dilleniales, and Ericales,and Malpighiales (McRae angipsperm wood type

1); more specific referals to genera of the Lauraceae and cf. Dilleniaceae from the McRae Fm are included in thos families below.

Phylognies and age estimates based on molecular evidence are included where these estimates cite fossil records. The appendicies, indices, and tables from books on the late Cretaceous and Cenozoic of North America (Graham, 1999), Latin America (Graham, 2010), general summaries for the New World (*Natural History*, Graham, 2011; *Land Bridges*, 2018; *Migrations*, in press), and the online https://www/press.uchicago.edu/sites/graham are additional sources of information.

The primary purpose of the catalog is to provide initial leads to the taxa and original literature for investigators seeking the data for their own use. It is a working, in-progress compilation rather than a finished manuscript. Hence, most of the above notes pertain to the original 2011 Catalog while addtions and references through the current version are listed in the Addendum under Reviews/General below. Some inconsistencies in format and information result from the on-going nature of the work and various ways the data are presented in the original publications.

REVIEWS/GENERAL

Baker, P. A. et al. (+ 8 authors). 2014. The emerging field of geogenomics: Constraining geological problems with genetic data. Earth-Science Reviews 135: 38-47.

Flantua, S. G. A., H. Hooghiemstra, J. H. Van Boxel, M. Cabrera, Z. González-Carranza, and C. González-Arango. 2014. Connectivity dynamics since the last glacial maximum in the northern Andes: a pollen-driven framework to assess potential migration. In: Stevens, W. D., O. M. Montiel, and P. H. Raven (eds). Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th Year. Missouri Botanical Garden Press, St. Louis. Pp. 98-123.

Greenwood, D. R., K. B. Pigg, J. F. Basinger, and M. L. DeVore. 2016. A review of paleobotanical studies of the early Eocene Okanagan (Okanogan) Highlands floras of British Columbia, Canada, and Washington, USA. Canadian Journal of Earth Sciences 53: 548-564.

Greenwood, D. R., K. B. Pigg, and M. L. DeVore. 2016. Eocene paleontology and geology of western North America. Canadian Journal of Earth Sciences 53: 543-547.

Hughes, C. E., R. T. Pennington, and A. Antonelli. 2013. Neotropical plant evolution: Assembling the big picture. Botanical Journal of the Linnean Society 171: 1-18.

Lewis, L. R. et al. (+9 authors). 2014. First evidence of bryophyte diaspores in the plumage of transequatorial migrant birds. PeerJ 2: e424; DOI 10.7717/peerj.424.

Simon, M. F., R. Grether, L. P. de Queiroz, C. Skema, R. T. Pennington, and C. E. Hughes. 2009. Recent assembly of the Cerrado, a neotropical plant diversity hotspot, by in situ evolution of adaptations to fire. Proceedings of the National Academy of

Sciences USA 100: 20359-20364.

Simpson, B. B. 2014. Whence the flora of southern South America? Biases may distort our conclusions. In: Stevens, W. D., O. M. Montiel, and P. H. Raven (eds.). 2014. Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th Year. Missouri Botanical Garden Press, St. Louis. Pp. 338-366.

Stevens, W. D., O. M. Montiel, and P. H. Raven (eds.). 2014. Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th Year. Missouri Botanical Garden Press, St. Louis.

Utescher, T., A. A. Bruch, B. Erdel, L. François, D. Ivanov, F.M.B. Jacques, A. K. Kern, Y.-S. (C.) Liu, V. Mosbrugger, and R. A. Spicer. 2014. The coexistence approach—theoretical background and practical considerations of using plant fossils for climate quantification. Palaeogeography, Palaeoclimatology, Palaeoecology 410: 58-73.

ADDENDUM- In the presentation "The Miocene- Before and After" (2014) as part of the symposium "The Miocene Vegetation and Environment of Western North America (Botany14, Boise, Idaho meetings, Richard Dilhoff, Caroline Strömberg, Thomas Dilhoff, and Regan Dunn, organizers) it was noted that references mentioned/used in the presentation would be provided in this Catalog and Literature Guide. These are as follows:

Axelrod, D. I. 1958. Evolution of the Madro-Tertiary Geoflora. Botanical Review 24: 433-509.

Bacon, C. D., A. Mora, W. L. Wagner, and C. A. Jaramillo. 2013. Testing geological models of evolution of the Isthmus of Panama in a phylogenetic framework. Botanical

Journal of the Linnean Society 171: 287-300.

Barnosky, A. D. et al. (+ 40 authors). 2017. Merging paleobiology with conservation biology to guide the future of terrestrial ecosystems. Science 355: 594-603.

Bond, W. J. 2014. Fires in the Cenozoic: a late flowering of flammable ecosystems. Frontiers in Plant Science 5: 749.

Camilo Montes, A. C. et al. (+ 13 authors). 2012. Evidence for middle Eocene and younger land emergence in central Panama: Implications for Isthmus closure. Geological Society of America Bulletin 124: 780-799.

Chaney, R. W. 1959. Miocene floras of the Columbia Plateau. Part 1. Composition and interpretation. Carnegie Institution of Washington Contributions to Paleontology 617: 1-134.

Cúneo, N. R., M. A. Gandolfo, M. C. Zamaloa, and E. Hermsen. 2014. Late Cretaceous aquatic plant world in Patagonia, Argentina. PLoS One: https://doi.org/10.1371/journal.pone.0104749.

Davis, M. B. 1981. Quaternary history and the stability of forest communities. In : D. C. West, H. H. Shugart, and D. B. Botkinee (eds.), Forest Succession: Concepts and Applications. Springer-Verlag, Berlin. Pp. 132-153.

Dietl, G. P. and K. W. Flessa. 2011. Conservation paleobiology: Putting the dead to work. Trends in Ecology and Evolution 26: 30-37.

Dokka, R. and T. M. Ross. 1995. Collapse of southwestern North America and the evolution of early Miocene detatchment faults, metamorphic core complexes, the Sierra Nevada Orocline, and the San Andreas Fault System. Geology 23: 1075-1078.

Endara, L. et al. (+ 7 authors). 2017. Building the “Plant Glossary’—a controlled

botanical vocabulary using terms extracted from the Floras of North America and China. Taxon 66: 953-966.

Engler, A. 1879/1882. Versuch einer Entwicklungsgeschichte der Pflanzenwelt seit der Tertiäperiode I/II. W. Engelmann, Leipzig. [p. 203].

Estrada-Ruiz, E., L. Calvillo-Canadell, and R. S. Cevallos-Ferriz. 2009. Upper Cretaceous aquatic plants from northern Mexico. Aquatic Botany 90: 282-288.

Fedorov, A. V., C. M. Brierley, K. T. Lawrence, Z. Liu, P. S. Denkens, and A. C. Ravelo. 2013. Patterns and mechanisms of early Pliocene warmth. Nature 496: 43-49.

Goes, S. 2013. Western North America's jigsaw. Nature 496: 35-37.

Graham, A. 1999. Late Cretaceous and Cenozoic History of North American Vegetation. Oxford University Press, Oxford, U.K.

-----. 2003. Historical phytogeography of the Greater Antilles. Brittonia 55: 357-383.

-----. 2011. The age and diversification of terrestrial New World ecosystems through Cretaceous and Cenozoic time. American Journal of Botany 98: 336-351.

-----. 2015. Past ecosystem dynamics in fashioning views on conserving extant New World vegetation. Annals of the Missouri Botanical Garden 100: 150-158.

[see also]:

-----. 2010. Late Cretaceous and Cenozoic History of Latin American Vegetation and Terrestrial encironments. Missouri Botanical Garden Press, St. Louis.

-----. 2011. A Natural History of the New World, the Ecology and Evolution of Plants in the Americas. University of Chicago Press, Chicago.

-----. 2014. Academic Tapestries, Fashioning Teachers and Researchers out of Events and Experiences. Missouri Botanical Garden Press, St. Louis.

-----. 2018. Land Bridges, Ancient Environments, Plant Migrations, and New World Connections. University of Chicago Press, Chicago.

-----. In press. [tentative working title]: Late Cenozoic Migration and Conservation of New World Vegetation- the Last Chapter. University of Chicago Press, Chicago. [see also Stevens et al., 2014]

Graham, S. 2013. Fossil records in the Lythraceae. Botanical Review 79: 48-145.

Grein, M., W. Konrad, V. Wilde, T. Utescher, and A. Roth-Nebelsick. 2011. Reconstruction of atmospheric CO_2 during the early middle Eocene by application of a gas exchange model to fossil plants from the Messel Formation, Germany. Palaeogeography, Palaeoclimatology, Palaeoecology 309: 383-391.

-----, C. Oehm, W. Konrad, T. Utescher, L. Kunzmann, and A. Roth-Nebelsick. 2013. Atmospheric CO_2 from the late Oligocene to early Miocene based on photosynthesis data and fossil leaf characteristics. Palaeogeography, Palaeoclimatology, Palaeoecology 374: 41-51.

Grimsson, F., R. Zetter, and C.-C. Hoffman. 2011. *Lythrum* and *Peplis* from the Late Cretaceous and Cenozoic of North America and Eurasia: New evidence suggesting early diversification within the Lythraceae. American Journal of Botany 98: 1801-1815.

Hedges, S. B. 2006. Historical zoogeography of the West Indes. In: A. Graham (ed.), The Biogeography of Latin America—Causes and Effects. Annals of the Missouri Botanical Garden 93: 231-244.

Henry, C. D. 2009. Uplift of the Sierra Nevada, California. Geology 37: 575-576.

Houben, A. et al. (+ 14 authors and the Expedition 318 Scientists). 2013.

Reorganization of the Southern Ocean plankton ecosystem at the onset of Antarctic glaciation. Science 340: 341-344.

House, M. A., B. P. Wernicke, and K. A. Farley. 1998. Dating topography of the Sierra Nevada, California, using Apatite (U-Th)/He ages. Nature 396: 66-669.

Itrralde-Vinent, M. A. and R. D. E. MacPhee. 1999. Paleogeography of the Caribbean region: Implications for Cenozoic biogeography. Bulletin of the American Museum of Natural History 218: 1-95.

Jiménez-Mejías, P. et al. 2016. A commented synopsis of the pre-Pleistocene fossil record of *Carex* (Cyperaceae). Botanical Review 82: 258-345.

Kay, R. F. in press/on line. Biogeography in deep time—what do phylogenetics, geology, and paleoclimate tell us about early platyrrhine evolution? Molecular Phylogenetics and Evolution.

Malumián, N. and C. Nañéz. 2011. The Late Cretaceous-Cenozoic transgressions in Patagonia and the Fuegian Andes: Foramiinifers, palaeoecology, and palaeogeogaphy. Biological Journal of the Linnean Society 103: 269-288.

Mason, H. L. 1947. Evolution of certain floristic associations in western North America. Ecological Monographs 17: 201-210.

Millar, C. 2011 (in manuscript/online 2012). Geologic, climatic, and vegetation history of California. Pacific Southwest Research Station, U.S. Forest Service. www.fs.us/psw/publications/millar/psw_2012.

Mitchell, J. S., P. D. Roopnarine, and K. D. Angielczyk. 2012. Late Cretaceous restructuring of terrestrial communities facilitated the end-Cretaceous mass extinction in North America. Proceedings of the National Academy of Sciences USA 109: 18857-

18861.

Mulch, A., S. A. Graham, and P. C. Chamberlain. 2008. Hydrogen isotopes in Eocene gravels and paleoelevation of the Sierra Nevada. Science 313: 87-89.

O'Dea, A., N. Hoyos, F. Rodríguez, B. Degracia, and C. De Gracia. 2012. History of upwelling in the Tropical Eastern Pacific and the paleogeography of the Isthmus of Panama. Palaeogeography, Palaeoclimatology, Palaeoecology 348-349: 59-66.

Palazzesi, L. and V. Barreda. 2012. Fossil pollen records reveal a late rise of open-habitat ecosystems in Patagonia. Nature Communications 3: 1294. doi: 10.1038.ncomm2299.

Pound, M. J., A. M. Haywood, U. Salzmann, J. B. Riding, D. J. Lunt, and S. J. Hunter. 2011. A Tortonian (late Miocene, 11.61-7.25 Ma) global vegetation reconstruction. Palaeogeography, Palaeoclimatology, Palaeoecology 300: 29-45.

Quattrocchio, M. E., M. A. Martínez, L. F. Hinojosa, and C. Jaramillo. 2013. Quantitative analysis of Cenozoic palynofloras from Patagonia, southern South America. Palynology 37: 246-258.

Raymo, M. E. and W. F. Ruddiman. 1992. Tectonic forcing of late Cenozoic climate. Nature 359: 117-122.

Retallack, G. J. 2013. Global cooling by grassland soils of the geologic past and near future. Annual Review of Earth and Planetary Sciences 41: 69-86.

Sigloch, K. and M. G. Mihalynuk. 2013. Intra-oceanic subduction shaped the assembly of cordilleran North America. Nature 496: 50-56.

Stevens, W. D., O. M. Montiel, and P. H. Raven (eds.). 2014. Paleobotany and Biogeography, a Festschrift for Alan Graham in His 80th Year. Missouri Botanical

Garden Press, St. Louis.

Strömberg, C. A. E., R. E. Dunn, R. H. Madden, M. J. Kohn, and A. A. Carlini. 2013. Decoupling the spread of grasslands from the evolution of grazer-type hervores in South America. Nature Communications, doi: 10.1038/ncomms2508.

Tiffney, B. H. 1985. The Eocene North Atlantic land bridge: Its importance in Tertiary and modern phytogeography of the Northern Hemisphere. Journal of the Arnold Arboretum 66: 243-273.

Wen, J. 1999. Evolution of eastern Asian and eastern North American disjunct distribution in flowering plants. Annual Review of Ecology and Systematics 30: 421-455.

----- and S. M. Ickert-Bond. 2009. Evolution of the Madrean-Tethyan disjunctions and the North and South American amphitropical disjunctions in plants. Journal of Systematics and Evolution 47: 331-348.

-----, -----, Z. Nie, and R. Li. 2010. Timing and modes of evolution of Eastern Asian-North American biogeographic disjunctions in seed plants. In: M., Long, H. Gu, and Z. Zhou (eds.), Darwin's Heritage Today. Proceedings of the Darwin 200 Beijing International Conference. Higher Education Press, Beijing, China. p. 252-269.

Wernicke, B. P. (+ 18 authors). 1996. Origin of the high mountains in the continents: The Sierra Nevada. Science 271: 190-193.

Wolfe, J. A. 1977. Paleocene floras from the Gulf of Alaska region. U. S. Geological Survey Professional paper 997: 1-108. [For discussion of geoflora concept see pp. 37-43].

Yang, J., R. A. Spicer, E. Teresa, and V. Spicer. 2011. 'CLAMP Online': a new web-

based palaeoclimate tool and its application to the terrestrial Paleogene and Neogene of North America. Palaeobiodiversity and Palaeoenvironments 91: 163-183.

You, Y., M. Huber, R. D. Müller, C. J. Poulsen, and J. Ribbe. 2009. Simulation of the middle Miocene climate optimum. Geophysical Research Letters 36: published online, doi: 10.1029/2008GLO36751.

Zachos, J., M. Pagani, L. Sloan, E. Thomas, and K. Billups. 2001. Trends, rhythms, and abberations in global climate 65 Ma to present. Science 292: 686-693.

FILICINEAE (and associated non-seed vascular plant groups)

General summaries- Collinson, 2001; Rothwell, 1999; Cretaceous cicatricose (*Anemia, Mohria*) spores, Argentina- see Narváez et al., 2013).

INCERTAE SEDIS (Filicineae)

Cladophlebis cinerrium- Cretaceous (Aptian), Anfiteatro de Ticó Fm., Santa Cruz Province, Argentina, fronds, rhizomes, adventitious roots; Carrizo et al., 2011.

Striatisperma coronapunctatum- middle Eocene (44 Ma), Clarno Fm., OR, Manchester, 1994 = *Equisetum* root nodules (Steven Manchester, pers. comm., April, 2011).

Cryptogam spores from the Late Cretaceous (Campanian) to Paleocene of Seymour Island, Antarctica (Askin, 1989) identified by a morphological system necessitated by the age of the deposits include *Clavifera triplex* (gleicheniaceous fern) and massulae of *Azolla*-type (salviniaceous; pp. 112-113).

Acrostichum type (Pteridaceae)- late Miocene, Upper Belugia Fm., south coast Alaska, spore; Reinink-Smith & Leopold, 2005.

Adiantopsis (Pteridaceae)- Link-Pérez et al. (2011): "Biogeograpahic analyses suggest an origin for the genus in South America, with a minimum of three migrations into the Caribbean") p. 1255).

Allantodiopsis (undetermined genus, Dryopteridaceae)- late Miocene, Vasa Park Fl., King Co., WA, leaf; Dillhoff et al., 2014.

Anemia quatsinoensis (Schizaeaceae)- Lower Cretaceous, Longarm Fm. equivalent, Apple Bay locality, Vancouver Is., British Columbia, Canada, vegetative and fertile organs; Hernandez-Castillo et al., 2006. ?*A.* type- late Miocene, Upper Beluga Fm., south coast Alaska, spore; Reinink-Smith & Leopold, 2005.

Arcellites humilis, A. pentagonalis, A. santacrucensis, A. sp. A (Marsileaceae)- Cretaceous (late Albian possibly extending into the Cenomanian), Argentina, Patagonia, spores; Villar de Seoane & Archangelsky, 2008.

Azolla (Azollaceae)- "…the *Azolla* event of 49m years ago- a giant bloom…that coincided with one of the biggest climatic shifts known" (Economist, 2014). *Azolla* sp.- Maastrichtian to lowermost Danian López de Bertodiano Fm., Seymore Island, Antarctica, spores; Bowman et al., 2014 [numerous other palynomorphs identified to genus by artificial system, some referred to family- e.g., Polypodiaceae, Araucariaceae, Podocarpaceae, Ericaceae, Loranthaceae, Monimiaceae, Nothofagaceae, Proteaceae, Ranunculaceae].

Azolla circinata (Azollaceae)- Late Cretaceous, Loncoche Fm., Mendoza, Argentina, massulae; Puebla et al., 2014. *A. stanleyi* (Azollaceae)- late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada, Hoffman & Stockey, 1994, 1999; Pigg & DeVore, 2010. *A.* sp.- Paleogene, Ñirihuau Basin, Argentina, megaspores; Quattrocchio et al., 2012. Late Miocene, Upper Beluga Fm., south coast Alaska, megaspore; Reinink-Smith & Leopold, 2005.

Baculatisporites comaumensis (Osmundaceae)- Paleogene, Ñirihuan Basin, Argentina, spores; Quattrocchio et al., 2012. *B. primarius* (Osmundaceae)- late Paleocene (~60 Ma), Sagwon, North Slope, Alaska, spores; Daly et al., 2011. *B. turbioensis* (?Osmundaceae)- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012. *B.* sp. (cf. Osmundaceae)- late Paleocene, Almont Fl., Williston Basin, ND, spore; Zetter et al., 2011.

Bacutriletes guttula (Selaginellaceae)- Cretaceous (late Albian possibly extending into

the Cenomanian), Argentina, Patagonia, spores; Villar de Seoane & Archangelsky, 2008.

Balmeisporites holodictyus (Salviniaceae)- Cretaceous (late Albian possibly extending into the Cenomanian), Argentina, Patagonia, spores; Villar de Seoane & Archangelsky, 2008.

Biretisporites crassilabratus (?Hymenophylleaceae)- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012.

cf. *Boodlepteris* (Gleicheniaceae)- Late Cretaceous (late Santonian), Buffalo Creek Member, Gaillard Fm., Allon Fl., GA, pinnules; Herendeen et al., 1999.

Botrychium wightonii (Ophioglossaceae)- late Paleocene, Alberta Basin, Genesee Fl., Canada, Rothwell & Stockey, 1989; Pigg & DeVore, 2010. *B.* type- late Miocene, Upper Beluga Fm., south coast Alaska, spore; Reinink-Smith & Leopold, 2005.

Cicatricosisporites (some spores similar to those of modern species of *Anemia*), *Ruffordiaspora* (Anemiaceae)- Lower Cretaceous, Austral Basin, Patagonia, Argentina, spores; Archangelsky & Archangelsky, 2010.

Cingutriletes australis (*Sphagnum*)- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012.

Conantiopteris schuchmanii (Cyatheaceae)- Lower Cretaceous (Aptian), upper Chickabally Member, Budden Canyon Fm., near Cottonwood, CA, trunk, frond bases, adventitious roots; Lantz et al., 1999: [Cladistic analyses "indicate that the new genus is nested among a paraphyletic assemblage of dicksoniaceous, lophosoriaceous, and metaxylaceous species that subtend a monophyletic Cyatheaceae s.s.", p. 361].

Contignisporites cooksoniae, C. glebulentus, C. burgeri (Pteridaceae)- Early Cretaceous

(Hauterivian to Albian), Austral Basin, Argentina, Patagonia, spores; Archangelsky & Archangelsky, 2006.

Crybelosporites pannuceus (Marsileaceae)- Late Cretaceous, Loncoche Fm., Neuquén Basin, Mendoza, Argentina, microspore; Puebla et al., 2014.

Cryptogramma (Pteridaceae)- late Miocene, Upper Beluga Fm., south coast Alaska, spore; Reinink-Smith & Leopold, 2005.

Cyathea cranhamii (Cyatheaceae)- Early Cretaceous (Barremian), Longarm Fm. equivalent, Apple Bay locality, Vancouver Is., British Columbia, Canada, sori (indusia, sporangia with annulus, spores); Smith et al., 2003.

Cyatheacidites annulatus (*Lophosoria*, Lophosoriaceae)- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012.

Cyathidites subtilis (Cyatheaceae/Dicksoniaceae)- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012.

Davallia (Davalliaceae)- late Miocene, Upper Beluga Fm., south coast Alaska, spore; Reinink-Smith & Leopold, 2005.

Deltoidospora adriennis (Pteridaceae)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope, Alaska, spores; Daly et al., 2011. *D. australis, D. minor* (Polypodiaceae, *Acrostichum*)- Paleogene, Ñirihuau Basin, Argentina, spore; Quattrocchio et al., 2012.

Dennstaedtia blomstrandii (Dennstaedtiaceae)- late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada; Hoffman & Stockey, 1999.

Dickwhitea allenbyensis (Athyriaceae)- middle Eocene, Allenby Fm., Princeton Chert Member, British Columbia, Canada, rhizome; Karafit et al., 2006.

Dictyophyllidites harrisii (Matoniaceae, *Phlebopteris*)- Paleogene, Ñirihuau Basin,

Argentina, spore; Quattrocchio et al., 2012.

Dryopteris sp. (Dryopteridaceae)- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. cf. *Dryopteris*- late Miocene, Upper Beluga Fm., south coast Alaska, spore; Reinink-Smith & Leopold, 2005.

Equisetum lyellii (Equisetaceae; see also Incertae Sedis, Filicineae)- Lower Cretaceous (upper Albian), Potomac Group, VA, stem; Upchurch et al., 1994. *E.* sp.- late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada, Hoffman & Stockey, 1999; late Paleocene (Tiffanian)- Paskapoo Fm., Alberta, Canada, stems, rhizomes, tubers, Stockey et al., 2014; middle Eocene (45 Ma), Thunder Mountain Fl., ID, underground tubers, Axelrod, 1998; Oligocene (30.7 Ma), Haynes Creek Fl., ID, Axelrod, 1998a ; Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, stem, Meyer & Manchester, 1997; late Miocene, Vasa Park Fl., King Co., WA, spore, bulbil, nodal sheath, spore(?), Dillhoff et al., 2014; late Miocene (Clarendonian, 12 Ma), Ironside Fm., OR, Retallack, 2004; Miocene (15-6 Ma), Iceland, Grimsson & Denk 2007.

Gleichenia appianensis (Gleicheniaceae)- middle Eocene, Oyster Bay Fm., Appian Way locality, Vancouver Is., British Colombia, Canada; Mindell et al., 2006.

Gleicheniidites argentinus (Gleicheniaceae)- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012.

Goolangia minnesotensis (Marattiaceae)- Cretaceous (latest Albian to earliest Cenomanian), Dakota Fm., Courtland Clay Pit, New Ulm, central MN, sporangia and

synangia; Hu et al., 2006.

Grapnelispora (extinct)- Late Cretaceous, Loncoche Fm., Neuquén Basin, Mendoza, Argentina, megaspore; Puebla et al., 2014.

Hausmannia morinii (Dipteridaceae)- Lower Cretaceous (Hauterivian-Barremian boundary), Longarm equivalent, Apple Bay locality, Vancouver Is., British Colombia, Canada, foliage; Stockey et al., 2006a.

Hydropteris pinnata (for family relationships see Pryer, 1999)- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Hymenophyllopsis (Hymenophyllopsidaceae)- late Miocene, Upper Beluga Fm., south coast Alaska, spore; Reinink-Smith & Leopold, 2005.

Hymenophyllum (Hymenophyllaceae)- late Miocene, Upper Beluga Fm., south coast Alaska, spore; Reinink-Smith & Leopold, 2005. cf. *Hymenophyllum caudiculatum*- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012.

Ischyosporites aerapunctatis (Dicksoniaceae)- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012.

Isoëtes horridus (Isoëtaceae)- late Paleocene, Williston Basin, Beicegel, Golden Valley, Ravenscrag Fls., US/Canada, Brown, 1962, Hickey, 1977, McIver & Basinger, 1993, Pigg & DeVore, 2010. *I.* cf. *horridus*- late Paleocene, Beicegel Fl., megaspores; Matthews et al., 2007. *I.* sp.- late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada; Hoffman & Stockey, 1999.

Kuylisporites (*K. mirabilis, K. separatus, K. scutatus, K. waterbolkii*; Cyatheaceae)- Cretaceous, Cenozoic, widespread, spores; Mohr & Lazarus, 1994: ["…genus originated in the Northern Hemisphere in the late Cretaceous; *K. waterbolkii*…closely

related to or identical with extant *Cnemidaria*…" , p. 765].

Laevigatosporites hardtii (Polypodiaceae)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, spores; Daly et al., 2011. *L. ovatus* (Blechnaceae)- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012. *L.* sp. (Thelypteridaceae)- Miocene, Tepoztlán Fm., Mexico, spores; Lenhardt et al., 2013.

Leptolepidites macroverrucosus (Dennstaedtiaceae)- Paleogene, Ñirihuau Basin, spores; Quattrocchio et al., 2012.

Lomaridium (Blechnaceae: Polypodiopsida)- 'Most species in the family were recognized under a single large genus *Blechnum* until recently when a new classification proposed…24 genera; two data sets from three plastid markers…date the origin of *Lomaridium* at some point during the Paleocene in [broadly] Australia plus tropical Central and South America' with 'long-distance dispersal events' (p. 1304); Vicent et al., 2017.

Lycopodium Lycopodiaceae)- late Miocene, Upper Beluga Fm., south coast Alaska, spore; Reinink-Smith & Leopold, 2005. Late Miocene, Vasa Park Fl., King County, WA, spore; Dilhoff et al., 2014.

Lycopodiumsporites reticulates (Lycopodiaceae)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, spores; Daly et al., 2011.

Lygodium kaulfussii (Schizaeaceae)- Eocene, WY, foliage with intact sorophores, Manchester & Zavada, 1987, Pigg & DeVore, 2010. *L.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, spores, Leopold & Clay-Poole, 2001; late Miocene, Upper Beluga Fm., south coast Alaska, spore, Reinink-Smith & Leopold, 2005.

Makotopteris princetonensis (Athyriaceae)- middle Eocene, Princeton Chert, Princeton

Group, Allenby Fm., southern British Columbia, Canada, rhizomes, fronds, stipes, rachis, pinnules, sori, spores; Stockey et al., 1999: ["…documents that essentially modern athyrioids were present in the flora of North America by the early Tertiary" , p. 1047].

Matonisporites ornamentalis (Dicksoniaceae)- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012.

Mendozaphyllum loncochese (Marsileaceae)- Late Cretaceous, Neuquén Basin, Mendoza, Argentina, macrofossils; Puebla et al., 2014.

Mesozoisynanangia trilobus (Marattiaceae)- Cretaceous (latest Albian to earliest Cenomanian), Dakota Fm., Courtland Clay Pit, New Ulm, central MN, sporangia and synangia; Hu et al., 2006.

Midlandia nishidae (Blechnaceae)- Upper Cretaceous (Campanian), Horseshoe Canyon Fm., near Drumheller, Alberta, Canada, rhizomes, stipe bases; Serbet & Rothwell, 2006. ["…strongly support hypotheses that these highly derived ferns originated before the Upper Cretaceous" (p. 703)].

Millerocaulis embreei (Osmundaceae)- Early Cretaceous (Aptian), upper Chickabally Member, Budden Canyon Fm., near Ono, CA, stem; Stockey & Smith, 2000. [Other fossil records are listed in table 1, p. 164].

Minerisporites aequatus, M. laceratus (Isoetaceae)- Cretaceous (late Albian possibly extending into the Cenomanian), Argentina, Patagonia, spores; Villar de Seoane & Archangelsky, 2008.

Mohria-like spores (Anemiaceae)- Early Cretaceous (Albian), Piedra Clavada Fm., Austral Basin, Argentina, Patagonia; Archangelsky, 2009.

Muricingulisporis annulatus (Pteridaceae)- Early Cretaceous (Hauterivian to Albian), Austral Basin, Argentina, Patagonia, spores; Archangelsky & Archangelsky, 2006. *M. chenquensis*- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012.

Onoclea senisbilis (Dryopteridaceae)- late Paleocene, Alberta Basin, Munce's Hill Fl., Rothwell & Stockey, 1991, Pigg & DeVore, 2010; Stockey et al., 2014.

Osmunda cinnamomea (Osmundaceae)- Upper Cretaceous, Horseshoe Canyon Fm., near Drumheller, Alberta, Canada, small trunks, stems, frond bases; Serbet & Rothwell, 1999: [with other specimens "reveals the more or less continuous presence of *O. cinnamomea* L. in western North America for at least 70 million years", p. 425; includes other records, p. 427]. *O. macrophylla*- late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada; Hoffman & Stockey, 1999. *O. occidentale*- middle Eocene (45 Ma), Thunder Mountain Fl., ID, pinnules; Axelrod, 1998. Oligocene (30.7 Ma), Haynes Creek Fl., ID, pinnae; Axelrod, 1998a. *O. vancouverensis*- Lower Cretaceous, Longarm Fm. equivalent, Apple Bay locality, Vancouver Is., British Colombia, Canada, fertile fronds; Vavrek et al., 2006. *O. parschlugiana*, Miocene (15-6 Ma), Iceland; Grimmson & Denk, 2007. *O.* sp.- late Miocene, Upper Beluga Fm., south coast Alaska, spore; Reinink-Smith & Leopold, 2005.

Paleoazolla patagonica (Salvianiaceae)- Late Cretaceous, Neuquén Basin, Mendoza, Argentina, massulae; Puebla et al., 2014.

Paralygodium meckertii (Schizaeaceae)- Upper Cretaceous (Coniacian), Comox Fm., Eden Main localities, Vancouver Is., Bristish Colombia, Canada, fertile pinnules; Karafit & Stockey, 2008. *P. vancouverensis*- middle or late Eocene Appian Way locality, Vancouver Is., British Columbia, Canada, fertile pinnules; Trivett et al.,

2006: ["…supports interpretations that the diversity of Schizaeaceae s.l. was greater during the Cretaceous and Paleogene than it is today" (p. 675)].

Perinomonoletes sp. (Polypodiaceae, cf. *Asplenium*, *Blechnum*)- Miocene, Tepoztlán Fm., Mexico, spore; Lenhardt et al., 2013.

Peromonolites vellosus (Blechnaceae)- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012.

Polypodiaceae (taxonomically, stratigraphically, geographically widespread generalized monolete fern spores; e.g., Bowman et al., 2014, see *Azolla*).

Polypodium deweyensis (Polypodiaceae)- middle Eocene (45 Ma), Thunder Mountain Fl., ID, terminal portion pinnule blade; Axelrod, 1998. *P.* sp.- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997.

Polypodium vulgare complex- [Sigel et al., 2014, p. 1042: "The *P. vulgare* complex is resolved as sister to the Neotropical *P. plesiosorum* group and these, in turn, are sister to the Asian endemic *Pleurosoriopsis makinoi*. Using divergence time analyses incorporating previously derived age constraints and fossil data, we estimate an early Miocene origin for the *P. vulgare* complex and a late Miocene-Piocene origin for the four major diploid lineages of the complex, with the majority of extant diploid species diversification from the late Miocene through the Pleistocene. Finally, we use our node age estimates to reassess previous hypotheses, and to propose new hypotheses, about the historical events that shaped the diversity and current geographic distribution of the diploid species of the *P. vulgare* complex."

Polypodiisporites inangahuensis (Polypodiaceae)- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012.

Pteridophyta sp. (Dennstaedtiaceae)- Miocene, Tepoztlán Fm., Mexico, spores; Lenhardt et al., 2013.

"Pteris" silvicola (Pteridaceae)- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997.

Pterisorus radiata (family unknown, combines characters of Pteridaceae and tree ferns)- Lower Cretaceous (Valanginian-Hauterivian boundary), Longarm Fm. equivalent, Apple Bay locality, Vancouver Is., British Columbia, Canada, fertile frond; Rothwell & Stockey, 2006.

Regnellidinum thomas-taylorii (Marsileaceae)- Upper Cretaceous (Campanian-Maastrichtian), La Colonia Fm., Chubut Province, Argentina, rhizomes with roots, petiolate compound leaves; Cúneo et al., 2013.

Reticuloidosporites tenellis (Polypodiaceae)- Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012.

Retitriletes sp. (*Lycopodium*)- Miocene, Tepoztlán Fm., Mexico, spores; Lenhardt et al., 2013.

Rickwoodopteris hirsuta (Cyatheaceae)- Late Cretaceous (late Campanian), Spray Fm., Shelter Point, Vancouver Is., British Columbia, Canada, stem; Stockey & Rothwell, 2004.

Ruffordiaspora (see *Cicatricosisporites*)

Salvinia sp. (Salviniaceae)- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Schizaea (Schizaeaceae)- late Miocene, Upper Beluga Fm., south coast Alaska, spore; Reinink-Smith & Leopold, 2005.

Selaginella sp. (Selaginellaceae)- latest Eocene (34.1 Ma), Florissant Fl., CO, spores; Leopold & Clay-Poole, 2001. Late Miocene, Vasa Park Fl., King Co., WA, spore; Dillhoff et al., 2014.

Sotasporites elegans, S. triangularis, S. sp. (Pteridaceae)- Early Cretaceous (Hauterivian to Albian), Austral Basin, Argentina, Patagonia, spores; Archangelsky & Archangelsky, 2006.

Speirseopteris orbiculata (Thelypteridaceae)- late Paleocene (late Tiffanian), Paskapoo Fm., central Alberta, Canada, fronds, fertile pinnules, spores; Stockey et al., 2006b; Pigg & DeVore, 2010; Stockey et al., 2014

Stereisporites sterieoides (Sphagnaceae, *Sphagnum*)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, spores; Daly et al., 2011. *S.* sp. (cf. *Sphagnum*)- Miocene. Tepoztlán Fm., spores; Lenhardt et al., 2013.

Stramineopteris aureopilosus (family unknown)- Lower Cretaceous (Valanginian to Hauterivian), Longarm Fm. equivalent, Apple Bay locality, Vancouver Is., Bristish Colombia, Canada, rhizomes, stipe bases, adventitious roots; Little et al., 2006.

cf. Thelypteridaceae- late Paleocene, Almont Fl., Williston Basin, ND, spore; Zetter et al., 2011.

Todea amissa (Osmundaceae)- early Eocene (ca. 52 Ma), Laguna del Hunco Fl., Chubut Province, Argentina, fertile and sterile pinnae; ‘extinct in South America but extant in Australasian rainforests; no ferns have been previously described from Laguna del Hunco; Carvalho et al., 2013.

Trawetsia princetonensis (Blechnaceae)- middle Eocene, Allenby Fm., Princeton Chert Member, British Columbia, Canada, rhizomes, stipes, fronds; Smith et al., 2006.

Verrucingulatisporites sp. (Pteridaceae)- Miocene, Tepoztlán Fm., Mexico, spores; Lenhardt et al., 2013.

Wessiea oroszii (Dryopteridaceae)- Upper Cretaceous (Campanian), Horseshoe Canyon Fm., near Drumheller, Alberta, Canada, rhizomes, stipe bases; Serbet & Rothwell, 2006; *W. yakimaensis*- middle Miocene, Grande Ronde Basalt of the Columbia River Basalt Group, 15.6 +/- 0.2 Ma, Yakima County, WA, rhizomes, frond bases; Pigg & Rothwell, 2001.

Woodwardia gravida (Blechnaceae)- Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora; Johnson, 2002. *W. virginica,* middle Miocene, Grande Ronde Basalt of the Columbia River Basalt Group, 15.6 +/- 0.2 Ma, Yakima County, WA, pinules, rhizomes, stipes, indusiate sori, and sporangia; Pigg & Rothwell, 2001: ["… emphasize the exceptional species longevity of some homosporous pteridophytes", p. 777]. *W.* sp.- late Paleocene, Williston Basin, Beicegel, Ravenscrag Fls., U.S./Canada, fronds, McIver & Basinger, 1993; Pigg & DeVore, 2010; Pigg et al., 2006 (Beicegel Fl.); late Miocene, Vasa Park Fl., King Co., WA, leaf, Dillhoff et al., 2014.

GYMNOSPERMAE

Gymnosperm microfossils from the Late Cretaceous (Campanian) to Paleocene of Seymour Island, Antarctica (Askin, 1989) identified by a morphological (vs. a biological) system necessitated by the age of the deposits include *Phyllocladidites mawsonii* (cf. extant *Lagarostrobus franklini*, western Tasmanian rainforest), *Phyllocladidites* types, and "pollen related to extant *Dacrydium, Dacrycarpus, Podocarpus, and Microcachrys* species" (p. 113), in addition to *Cycadopites* (Cycadales or Ginkgoales), *Araucariacites*

australis), and *Ephedra notensis* ("…which first appeared during the Maastrichtian throughout the Weddelian Province", p. 114).

ARAUCARIACEAE- Escapa & Catalano (2013): "Results support the monophyly of living and fossil *Araucaria* (including *Araucarites*), whereas the remaining extinct genera are placed as the stem of the agathioid clade" (p. 1153). …"depict *Araucaria* as the sister group of the agathioid clade formed by *Wollemia* and *Agathis*" (p. 1163). "…inferred the diversification of the crown group of *Araucaria* at the Late Cretaceous-Paleocene" (p. 1164). "…whereas the *Araucaria* clade achieved its modern morphology at least by the Middle Jurassic, the evidence presented here suggests that the acquisition of drived traits present in extant species of the agathian clade occurred much later, during the Cretaceous or Paleogene" (p. 1164). [see also *Azolla,* Bowman et al., 2014].

Alkastrobus peltatus- Early Cretaceous (Aptian), Anfiteatro de Ticó Fm., Baqueró Group, Santa Cruz Province, Argentina, Patagonia, pollen cone associated with twigs and leaves of *Brachyphyllum mirandai* with in situ pollen of *Cyclusphaera psilata*; Del Fueyo & Archangelsky, 2005; Archangelsky & Del Fueyo, 2010.

Araucaria grandifolia (Section *Araucaria*)- Early Cretaceous (Aptian), Punta del Barco Fm., Baqueró Group, Santa Cruz Province, Argentina, Patagonia, branches with leaves; Archangelsky & Del Fueyo, 2010.

cf. *Araucaria* sp.- Lower Cretaceous, Crato Fm., Araripe Basin, Brazil, strobilus, squamata (= cone scales); Kunzmann et al., 2004.

Araucariaceae (cf. *Araucaria* sect. *Eutacta*)- middle Eocene, Antarctic Peninsula, leaf; Poole et al., 2005.

Araucariacites australis- lower middle Eocene, Antarctic Peninsula, pollen; Poole et al.,

2005. Paleogene, Ñirihuau Basin, Argentina, spores; Quattrocchio et al., 2012.

A. sp.- late Paleocene, Almont Fl., Williston Basin, North Dakaota, pollen; Zetter et al., 2011.

Araucarioid wood types 1-3- Upper Cretaceous (Aguja, Javelina Fms.) and Paleocene (Black Peaks Fm.), Big Bend National Park, TX; Wheeler & Lehman, 2005.

Araucariostrobus sp. (aff. Araucariaceae)- Lower Cretaceous, Crato Fm., Araripe Basin, Brazil, cones attached to leafy shoots; Kunzmann et al., 2004.

Araucariopitys- Late Cretaceous (Coniacian to Campanian), Antarctic Peninsula, wood, pollen; Poole et al., 2005.

Araucarioxylon- Late Cretaceous (late Maastrichtian), mid-early Paleocene, lower middle Eocene, Antarctic Peninsula, wood (Maastrichtian with pollen), Poole et al., 2005.

Araucarioxylon sp. 2- Cretaceous (mid-Aptian) Cerro Negro Fm., Byers Peninsula, Livingston Island, Antarctica, wood;Falcon-Lang and Cantrill (2001; see table 1 for taxa listing and details of anatomical features).

Araucariacites australis- Late Cretaceous (late Maastrichtian), Antarctic Peninsula, pollen; Poole et al., 2005.

Araucarites aquiensis- Lower Cretaceous (upper Albian), Potomac Group, VA, cone scales; Upchurch et al., 1994.

Brachyphyllum obesum (cf. Araucariaceae)- Lower Cretaceous, Crato Fm., Araripe Basin, Brazil, vegetative shoots; Kunzmann et al., 2004.

Cyclusphaera radiata- Cretaceous (Albian), Piedra Clavada Fm., Santa Cruz Province, Patagonia, Argentina, pollen; Del Fueyo et al., 2012.

Dammarites sp.- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora;

Johnson, 2002.

Elatides longifolia- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Nothopehuen brevis- Early Cretaceous (Aptian), Baqueró Group, Santa Cruz Province, Argentina, Patagonia, twigs with leaves of the *Brachyphyllum* type; Archangelsky & Del Fueyo, 2010.

?BENNETTITALES

Sahinoxylon sp.- Cretaceous (mid-Aptian) Cerro Negro Fm., Byers Peninsula, Livingston Island, Antarctica trunk wood; Falcon-Lang and Cantrill, 2001.

CEPHALOTAXACEAE

Cephalotaxus nevadensis- middle Eocene (45 Ma), Thunder Mountain Fl., ID, needle; Axelrod, 1998. *C*.-type- middle Eocene, Republic Fl., WA; Schorn & Wehr, 1996.

CHEIROLEPIDIACEAE (Coniferales, extinct)

Pseudofrenelopsis parceramosa- Lower Cretaceous (upper Albian), Potomac Group, VA, shoots; Upchurch et al., 1994.

CUPRESSACEAE (see also Taxodiaceae)

"…Cupressaceae (162 species, 32 genera) exhibit patterns expected from the Jurassic/Cretaceous breakup of Pangea…originated during the Triassic…vicariance occurred around 153 Ma (124-183 Ma), when Gondwana and Laurasia were separating" Mao et al., 2012, p. 7793).

"Phylogenetic studies demonstrate that…these taxa all share a single common ancestor; by extension, they also share a common ancestral habitat. We conclude that the modern

biogeography of the Cupressaceae conifers was shaped in large part by their capacity to adapt to drought" (Pittermann et al., p. 9647).

Athrotaxis ungeri- Early Cretaceous (Aptian Anfiteatro de Ticó Fm., early Albian Piedra Clavada Fm., late Albian Kachaike Fm.), Argentina, Patagonia, Alexander Is., Antarctica, branches, leaves, ovuliferous cones; Archangelsky & Del Fueyo, 2010.

Calocedrus schornii- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf, ovulate cone; Meyer & Manchester, 1997. cf. *C.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, leafy twigs; Dillhoff et al., 2005.

Chamaecyparis sp. [*C. edwardsii* in Axelrod, 1998, p. 32; 1998a, p. 41]- middle Eocene, Thunder Mountain Fl., central ID, vegetative axes; Erwin & Schorn, 2005: [["Radiometrically dated at 46-45 Ma, it [the Thunder Mountain Flora] represents one of the oldest montane conifer-dominated assemblages recovered from the Northern Hemisphere", p. 125]]. *C.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, leafy twigs, cones, Dillhoff et al., 2005; latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, cones, Manchester, 2001; middle Eocene, Republic Fl., WA, Schorn & Wehr, 1996. *C. edwardsii*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, terminal branchlets with leaves; Axelrod, 1998a. *C. linguaefolia*- late Miocene, Vasa Park Fl., King Co., WA, leaves, leafy twigs; Dillhoff et al., 2014.

Coronelia molinae (?Podocarpaceae)- Paleogene, Ligoria Márquez Fm, Argentina; foliar remains; Carpenter et al., 2018.

Cryptomeria-type- middle Eocene, Republic Fl., WA, branches; Schorn & Wehr, 1996.

Cunninghamiostrobus goedertii- early Oligocene, Jansen Creek Member, Makah Fm., northern shore Olympic Peninsula, WA, stems, leaves (cone axes of seed cones occur at

the same locality); Miller, 1990: "These remains are similar to those of the modern *Cunninghamia lanceolata* but differ from this species too much to be treated in the modern genus" (p. 970). [The deposit also contains *Picea eichhornii* (Miller, 1989), *Pinus buchananii* (Underwood & Miller, 1980), *Pinus escalantensis* (Banks et al., 1981), and *Pityostrobus makahensis* (Crabtree & Miller, 1989)].

Cunninghamia chaneyi- Oligocene (33.6-32.2 Ma), John Day Fm, Bridge Creek Fl., OR, leaf, cone scale; Meyer & Manchester, 1997. *C. hornbyensis*- Cretaceous (Campanian), Northumberland Fm., Nanaimo Group, Collishaw Point, Hornby Island, British Columbia, Canada; Brink et al., 2009. *C. marquetii*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, branchlets, cones; Axelrod, 1998a. *C.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, leafy twigs, cones; Dillhoff et al., 2005. *C. taylorii*- Upper Cretaceous (Campanian), Horseshoe Canyon Fm., Drumheller badlands,, Alberta, Canada, stems, leafy shoots, leaves, ovuliferous cones, pollen cones; Serbet et al. 2013.

Curpessinocladus interuptus- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, Megaflora, Johnson, 2002; Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora, Johnson, 2002.

Cupressinoxylon- Upper Cretaceous (Aguija, Javeline Fms.) and Paleocene (Black Peaks Fm.), Big Bend National Park, TX, wood, Wheeler & Lehman, 2005; middle Eocene, Lower middle Eocene, Antarctic Peninsula, leaf, wood (*Libocedrus*); Poole et al., 2005.

Dacrycarpus chilensis-Paleogene, Ligorio Márquez Fm, Argentina; foliar remains; Carpenter et al., 2018. *D. puertae*- Eocene, Laguna del Hunco (ca. 52.2 Ma) and Rio Río Pichileufú (ca. 47.7 Ma), Patagonia, Argentina (presently Southeast Asian and

Australasian rainforests; fossils indistinguishable from living *D. imbricatus* (montane, Burma to Fiji), seed cones, foliage, pollen; *C. chilensis* (Englehardt) comb. nov. proposed for Eocene vegetative material from Chile; Wilf, 2012.

Fitzroya cupressoides- last interglacial (MIS 5e- called Valdivia in southern Chile), Mancera interglacial sequence, Mancera Island, Chile, wood; Astorga & Pino, 2011.

Fokieniopsis catenulata- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, Megaflora, Johnson, 2002; Paleocene, Ludlow Member, Fort Union Fm., ND, SD, megaflora, Johnson, 2002. *F. praedecurrens*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, foliage; Meyer & Manchester, 1997.

Ginkgoales(?)- ?*Ginkgoites sp.*-Paleogene, Ligorio Márquez Fm, Argentina; foliar remains; Carpenter et al., 2018.

Glyptostrobus europaeus- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Ludlow Membeer of Fort Union Fm., ND, SD, megaflora, Johnson, 2002; late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada, Hoffman & Stockey, 1999; Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. *G.* sp.- Late Cretaceous (Maastrichtain), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002. *G.*-type- middle Eocene, Republic Fl., WA, branches; Schorn & Wehr, 1996.

Homalcoia littoralis- Eocene, Appian Way locality, south of Campbell River, Vancouver Is., British Columbia, Canada, pollen cones; Hernandez-Castillo et al., 2005.

Inaperturopollenites dubius (*Cupressus*), *I. hiatus* (*Metaseqouia*)- late Paleocene (~60 Ma), Sagwon, North Slope Alaska, pollen; Daly et al., 2011. *I.* sp. 1 (Cupressaceae)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Juniperus sp.- Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO; Gregory & McIntosh, 1996.

Metasequoia foxii- Paleocene (late Tiffanian), Paskapoo Fm., Munce's Hill, central Alberta, Canada, leaves, pollen cones, pollen, ovulate cones, seeds, Stockey et al., 2001; Falder et al., 1999, Pigg & DeVore, 2010; Stockey et al., 2014. *M. occidentalis*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora, Johnson, 2002; late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada, Hoffman & Stockey, 1999; late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, leafy twigs, cones, Dillhoff et al., 2005. *M.* sp.- Late Cretaceous (Maastrichtain), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; late Paleocene, Almont, ND, seeds, Pigg & DeVore (pers. comm. from Manchester); early Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, foliage, ovulate cones, seeds, pollen cones; Meyer, 2005; Meyer & Manchester, 1997. *Metasequoia*-like- Paleocene, Paskapoo Fm., near Red Deer, Alberta, Canada, seedlings, branches; Falder et al., 1999. [Deposits also include *Equisetum, Onoclea sensibilis,* and *Joffrea speirsii* (cercidiphyllaceous dicot, Crane & Stockey, 1985)]. *M.* sp.- middle Eocene, Republic Fl., WA; Schorn & Wehr, 1996.

Pilgerodendron uviferum- last interglacial (MIS 5e- called Valdivia in southern Chile), Mancera interglacial sequence, Mancera Island, Chile, wood; Astorga & Pino, 2011.

Sequoia abietina- Miocene (16-6 Ma), Iceland; Grimsson & Denk, 2007. *S. affinis*- middle Eocene (45 Ma), Thunder Mountain Fl., ID, branchlets, cones; Axelrod, 1998. Oligocene (30.7 Ma), Haynes Creek Fl., ID, foliage, cones; Axelrod 1998a. Oligocene

(33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997; cf. *Sequoia* sp.- middle Eocene, Thunder Mountain Fl., central ID, needle; Erwin & Schorn, 2005. *S.* sp.- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, Dillhoff et al., 2005; latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, cones, Manchester, 2001; middle Eocene, Republic Fl., WA, Schorn & Wehr, 1996; late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997.

Sequoia/Metasequoia- late Miocene, Vasa Park Fl., King Co., WA, pollen; Dillhoff et al., 2014.

Sequoiapollenites polyformosus (*Sequoia*)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, pollen; Daly et al., 2011.

Taxodiaceaepollenites sp. (taxodiaceous, cf. *Glyptostrobus, Metasequoia, Taxodium*)- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011.

Taxodioxylon sp.- Early Cretaceous (late Albian), Neptune Glacier Fm., Antarctica, wood; Archangelsky & Del Fueyo, 2010; Falcon-Lang & Cantrill, 2001.

Tetraclinis potlachensis- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, ovulate cone, seed; Meyer & Manchester, 1997.

Thuja dimorpha- middle Eocene (45 Ma), Thunder Mountain Fl., ID, branchlets; Axelrod, 1998. *T.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, leafy twigs, cones, Dillhoff et al., 2005; middle Eocene, Republic Fl., WA; Schorn & Wehr, 1996.

Thujopsis idahoensis- middle Eocene (45 Ma), Thunder Mountain Fl., ID, twig; Axelrod,

1998. *T.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, leafy twigs; Dillhoff et al., 2005.

CUPRESSOID/PODOCARPOID wood, short ray, tall ray groups- Upper Cretaceous (Aguja, Javelina Fms.), Paleocene (Black Peaks Fm.), Big Bend National Park, TX; Wheeler & Lehman, 2005.

CYCADALES

Astrozamia stockeyi- early Eocene Laguna del Hunco Fl. (52.2 Ma), Chubut, Patagonia, Argentina, frond, leaflets, spiny petiole; Wilf et al., 2016.

Brunoa santarrosensis (Zamiaceae)- Upper Cretaceous, Allen Fm., Bajo de Santa Rosa, Río Negro Province, Argentina, stems; Artabe et al., 2004.

Centricycas- Late Cretaceous (Coniacian to Campanian), Antarctic Peninsula, stem; Poole et al., 2005.

Cycadopitys- Late Cretaceous (late Maastrichtian), lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005.

Eostangeria pseudopteris (Cycadaceae)- late Paleocene, Green River Basin, WY, CO, UT; Kvaček & Manchester, 1999, Pigg & DeVore, 2010.

Nilssonia yukonensis- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Nilsoniocladus alaskensis (palaeolatitude 75º N)- latest Albian(?), Lower Killik Tongue, Chandler Fm., Alaska, branched stem with long and short shoots, leaf scars, foliage; Spicer and Herman, 1996. *N. chukotensis*-latest Albian-earliest Cenomanian Krivorechenskaya Fm., ne Russia (palaeolatitude 73º N). short shoots, leaf scars, foliage; Spicer and Herman, 1996.

Restrepophyllum chiguoides (Zamiaceae)- Early Cretaceous (Aptian), Anfiteatro Fm., Santa Cruz Provivnce, Argentina, leaf; Passalia et al., 2010.

Worsdellia bonettiae (Zamiaceae)- Upper Cretaceous, Allen Fm., Bajo de Santa Rosa, Río Negro Province, Argentina, stems; Artabe et al., 2004.

DOYLEALES

Doylea tetrahedrasperma- Early Cretaceous, Apple Bay locality, northern Vancouver Island, British Columbia; Rothwell and Stockey, 2016.

EPHEDRACEAE

Ephedra archaeorhytidosperma- Early Cretaceous (Barremian), Jianshangou Beds, Yixian Fm., Huangbanjigou village, Shangyuan District of Beipiao City, western Liaoning Province, NE China, fertile reproductive shoots and seeds; Yang et al., 2005. [Huang & Price (2003) give an age estimate of 8-32 Ma for extant *Ephedra*; see also papers on age estimates and former diversity based on fossils and molecules, Rydin et al. 2004; Rydin et al., 2006]. Ickert-Bond et al., 2009: "Results from a relaxed clock with an uncorrelated rates model and fossil-based calibration reveal that New World species are monophyletic and diverged from their mostly Asian sister clade some 30 mya, fitting with many other Beringian disjunctions. The split between the single North American and the single South American clade occurred approximately 25 mya, well before the closure of the Panamanian Isthmus. Overall, the biogeographic history of *Ephedra* appears dominated by long-distance dispersal, but finer-scale studies are needed to test this hypothesis" (p. 444). Ickert-Bond & Rydin, 2011: "Traverse ridges occur in several Early Cretaceous fossil seeds with affinity to *Ephedra*. However, our results indicate that the resemblance between these fossils and extant taxa with similar

features is superficial and convergent. In line with other recent studies, we find that Cretaceous ephedroids are extinct stem relatives to the extant clade" (p. 36). *E.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

Ephedripites sp. (*Ephedra*)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

GINKGOACEAE

Ginkgo adiantoides- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Sentinel Butte Fm., Almont, Beicegel, ND, leaves, seeds, ovulate stalks, Crane et al. 1990, Pigg & DeVore, 2010; Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaf; Axelrod, 1998a. *G. biloba, G. dissecta*- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage; Dillhoff et al., 2005. *G. cranei*- upper Paleocene, Sentinel Butte Fm., ND, ovulate organs, assocated leaves; Zhou et al., 2012. *G. dissecta*- middle Eocene, Republic Fl., WA (possibly a juvenile foliage form? Kathleen Pigg, pers. comm., 2011). *G.* sp.- late Paleoclene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada, Hoffman & Stockey, 1999; middle Eocene, Republic Fl., WA, Schorn & Wehr, 1996.

Monocolpopollenites tranquillus (*Ginkgo*)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, pollen; Daly et al., 2011.

Monosulcites crescentus- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011.

GNETALES

Drewria potomacensis- Lower Cretaceous (probably Aptian), Potomac Group, VA, stems, leaves, reproductive structures with seeds, dispersed pollen, aff. cf. *Welwitschia*;

Crane & Upchurch, 1987.

PINACEAE [see also *Cunninghamiostrobus,* Taxodiaceae]

Abies bracteata- Eocene and Oligocene (Colorado), Oligocene (Oregon), Miocene (Oregon, Nevada, Idaho), macrofossils; Leopold & Zaborac-Reed, 2014. *A. idahoensis*- Oligocene (30.7 Ma), Haynes Creek, Fl., ID, leafy branchlet, seeds; Axelrod, 1998a. A. *milleri*, late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, leafy twigs, cone scales, winged seeds, *Abies* pollen, Dillhoff et al. 2005; middle Eocene, Klondike Mountain Fm., Republic Fl., WA, seeds, leaves, cones, cone scales, Schorn & Wehr, 1986. *Abies* sp., cf. *Abies* sp. [*A. deweyensis* in Axelrod, 1998]- middle Eocene, Thunder Mountain Fl., central ID, vegetative axes, winged seeds, leaves; Erwin & Schorn, 2005. *A.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, seed, Manchester, 2001, pollen, Leopold & Clay-Poole, 2001; Oligocene (32.9 Ma), Pitch-Pinnacle Fl., CO, Gregory & McIntosh, 1996; Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, ovulate cone scale, Meyer & Manchester, 1997; Miocene (16-15 Ma), Iceland, Grimsson & Denk, 2007; late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014.

Abiespollenites sp. (*Abies*)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Abietineapollenites foveoreticulatus (*Picea*)- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011. *A. latisulcatus* (Pinaceae)- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011.

Abietites longifolius (undetermined leaves)- Lower Cretaceous (upper Albian), Potomac Group, VA; Upchurch et al., 1994.

Cedripites, aff. *Cedrus*- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005. cf. *Cedripites* (*Cedrus* sp.)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Cedrus sp. (pollen, extinct type)- latest Eocene (34.1 Ma), Florissant Fl., CO; Leopold & Clay-Poole, 2001. Late Miocene, Vasa Park Fl., King Co., WA, pollen; Dillhoff et al., 2014.

Dacrydium- late Miocene, Upper Beluga Fm., south coast Alaska, pollen (with *Dacrydiumites*), Reinink-Smith & Leopold, 2005.

Keteleeria ptesimosperma- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, seed; Meyer & Manchester, 1997.

Keteleeriaepollenites megasaccus- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Larix lemhiensis- Oligocene (30.7 Ma), Haynes Creek Fl., ID, cone, seeds; Axelrod, 1998a. *L.* sp. [*L. leonardii* in Axelrod, 1998]- middle Eocene, Thunder Mountain Fl., central ID, vegetative axes, winged seeds; Erwin & Schorn, 2005. See review of the fossil record of *Larix* by LePage & Basinger, 1995a (table 1): ("…long distributed throughout the high latitudes of North America and northeastern Asia but reached Europe only in the last few million years" p. 19). *L. altoborealis*- Eocene, Buchanan Lake Fm., Axel Heiberg Is., Canadian High Arctic, fertile and vegetative remains; LePage & Basinger, 1991, table 1. *L*. sp.- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. [see also *Pseudotsuga/Larix* (pollen) below].

Midoriphyllum piceoides (*Picea*-like)- Lower Cretaceous (Valanginian-Hauterivian boundary), Apple Bay locality, Vancouver Is., British Columbia, Canada, leaves; Stockey & Wiebe, 2008.

Picea sp. (winged seeds), *P.* sp. (vegetative axes, leaves), *P.* sp. A (ovulate cone) [*P.magna*, *P. coloradensis, P. deweyensis* in Axelrod, 1998]- middle Eocene, Thunder Mountain Fl., central ID; Erwin & Schorn, 2005. *P.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, leafy twigs, winged seeds, cones, *Picea* pollen, Dillhoff et al., 2005; middle Eocene, Republic Fl., WA, Schorn & Wehr, 1996; latest Eocene (34.1 Ma), Florissant Fl., CO, seeds, Manchester, 2001, pollen, Leopold & Clay-Poole, 2001. Late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014. *P. coloradensis, P. deweyensis, P. magna*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, seeds, cone; Axelrod, 1998a. *P.* sp. (sect. *Picea*)- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. *P.* sp.- Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO, Gregory & McIntosh, 1996; late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005.

Piceapollis spp. (*Picea*)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, pollen; Daly et al., 2011. cf. *Piceapollis* sp. (*Picea* sp.)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Pinus arnoldii- middle Eocene, Princeton Chert Fl., British Columbia, Canada, ovulate cone; Klymiuk et al., 2011.

Pinus baileyi (Subgenus *P. sensu*, Section *P. sensu*, cf. Subsection *P. sensu*)- middle Eocene, Thunder Mountain Fl., central ID, ovulate cone; Erwin & Schorn, 2005. *P.*

alvordensis, P. baileyii, P. ponderosoides, P. prestrobus- Oligocene (30.7 Ma), Haynes Creek Fl., ID, cones, seeds, leaves; Axelrod, 1998a. *P. johndayensis*, Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, foliage, ovulate cone, seed, pollen cone; Meyer & Manchester, 1997. *P.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001. cf. *Pinus crossii* (Subgenus *strobus, Subsection balfourianae*)- middle Eocene, Thunder Mountain Fl., central ID, 5-needled fascicles; Erwin & Schorn, 2005. *Pinus mathewsii* (subgenus *Pinus,* Subsection *contortae*)- Pliocene, basal unit 1 of the section, Ch'ijee's Bluff, Porcupine River, near Old Crow in the Bluefish Basin, Yukon Territory, Canada, ovulate cones; McKown et al., 2002. *P.* sp.- middle Eocene, Republic Fl., WA, Schorn & Wehr, 1996; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dilhoff et al., 2014.

Pinus mundayi- 'Here we describe the oldest known fossils attributable to the genus from the lower Cretaceous (Valanginian, ca. 133-140 Ma) part of the Chaswood Formation of Nova Scotia, Canada, charred long-shoots; preservation as charcoal and the occurrence of resin ducts, which produce flammable terpene in modern pines, show that *Pinus* has co-occurred with fire since its Mesozoic origin'; Falcon-Lang et al., 2016.

cf. *Pinus sanjuanensis* (Subsection ?*cembroides*)- middle Eocene, Thunder Mountain Fl., central ID, short, 2-needled fascicles; Erwin & Schorn, 2005.

cf. *Pinus*- late Paleocene, Beicegel Fl., ND, ovule cone, Pigg & DeVore, 2010 (pers. comm. from Manchester).

Pinus sp. (Subgenus *P. sensu*)- middle Eocene, Thunder Mountain Fl., central ID, long, 2-needled fascicles; Erwin & Schorn, 2005. *Pinus* sp. (subgenus indeterminate)-

middle Eocene, Thunder Mountain Fl., central ID, winged seeds, ovulate cones; Erwin & Schorn, 2005. [Axelrod, 1998 treats the Thunder Mountain specimens of *Pinus* as *P. alvordensis* (needles), *P. baileyii* (base of cone with cone scales), *P. balfouroides* (needles, cone scales, seeds), *P. resinosoides* (needles, seeds)]. *P.* sp.- middle Eocene (44 Ma), Clarno Fm., OR, wood, pollen, pollen cone; Manchester, 1994. *P.* sp.- Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO, Gregory & McIntosh, 1996; Miocene (15-6 Ma), Iceland, Grimsson & Denk, 2007.

Pinus (section Strobus), *P.* (Section *Pinus*) sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, cones, seeds; Manchester, 2001.

Pinus sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, leafy twigs, foliage, cones, winged seeds, *Pinus* pollen, Dillhoff et al., 2005; late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997.

Pinuspollenites elongates (*Pinus*)- late Paleocene, Almont Fl., Williston Basin, North Dakota, pollen; Zetter et al., 2011. *P.* sp. (*Pinus*)- Miocene, Tepoztlán Fm., pollen; Lenhardt et al., 2013.

Pityosporites spp. (*Pinus*)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, pollen; Daly et al., 2011.

Pityostrobus beardii- Late Cretaceous (Campanian), Spray Fm., Nanaimo Group, Shelter Point, Vancouver Is., British Columbia, Canada, cones; Smith & Stockey, 2002. [oldest *Pinus* cited as in the Cretaceous, p. 185; molecular estimate 128 +/- 4 Ma, Eckert & Hall, 2006]. *P. californiensis*- Lower Cretaceous (Aptian), Upper Chickabally Member, Budden Canyon Fm., near Ono, CA, cone; Smith & Stockey, 2001. *P. makahensis*- early Oligocene, Makah Fm., Olympic Peninsula, seed cone;

Crabtree & Miller, 1989.

Pseudolarix amabilis, P. wehrii- Eocene, Buchanan Lake Fm., Axel Heiberg Is., Canadian Arctic Archipelago, reproductive and vegetative remains; LePage & Basinger, 1995b: ["…The fossil record of *Pseudolarix* (Pinaceae) reveals wide distribution in North America and Eurasia from at least the Early Cretaceous (Berriasian) and possibly the Late Jurassic (Portlandian) to the Plio-Pleistocene", p. 910; tables 1-4 list other fossil records for the genus]. *P.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, cones, foliage, winged seeds, Dillhoff et al., 2005; *P. wehrii*- middle Eocene, Republic Fl., WA, Gooch, 1992.

Pseudotsuga glaucoides- middle Eocene, Thunder Mountain Fl., ID, cones, winged seeds; Axelrod, 1998. *P.* sp.- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. *P./Larix*- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001. *P./Larix* type, Late Miocene, Vasa Park Fl., King Co., WA., pollen, Dillhoff et al., 2014.

TCT (= Taxodiaceae/Cupressaceae/Taxaceae pollen undifferentiated) and *Sequoia affinis* pollen- latest Eocene (34.1 Ma), Florissant Fl., CO, Leopold & Clay-Poole, 2001; TCT- late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005.

Tsuga sp. [*T. mertensioides* in Axelrod, 1998]- Eocene, Thunder Mountain Fl., central ID, leaf, winged seed; Erwin & Schorn, 2005. *T. mertensoides*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, seeds; Axelrod, 1998a. *T.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, pollen, Dillhoff et al., 2005; middle Eocene, Republic Fl., WA, Schorn & Wehr, 1996; latest Eocene (34.1 Ma), Florissant

Fl., CO, pollen, Leopold & Clay-Poole, 2001; Miocene (15-6 Ma), Iceland, Grimsson & Denk, 2007; late middle to early late Miocene, Bryn Mawr Fm., pollen, Pazzaglia et al., 1997; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014.

PODOCARPACEAE [see also *Azolla*, Bowman et al., 2014].

Apterocladus- Early Cretaceous, Argentina, Patagonia, leaves, pollen cones with *Callialasporites* pollen; Archangelsky & Del Fueyo, 2010.

?Dacrycarpites australiensis- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Dacrycarpus chilensis (cf. modern *D. dacrydioides*, lowlands, New Zealand)- Eocene, Coronel, Chile, foliage; Wilf, 2012.

D. puertae (cf. modern *D. imbricatus*, montane, Burma to Fiji)- Eocene, Laguna del Hunco (ca. 52.2 Ma), Patagonia, Argentina, Río Pichileufú (47.7 Ma), Argentina, seeds, cones, foliage, pollen; Wilf, 2011.

Dacrydimites florinii- Late Cretaceous (late Maastrichtian), mid-early Paleocene, lower middle Eocene, Antarctic Peninsula, pollen, Poole et al., 2005.

Microcachyridites antarcticus (*Microcachrys*)- mid-early Paleocene, lower middle Eocene, Antarctic Peninsula, pollen, Poole et al., 2005. Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012. *M.* sp.- Late Cretaceous (late Maastrichtian), Antarctic Peninsula, pollen; Poole et al., 2005.

Morenostrobus- Early Cretaceous, Patagonia, Argentina, leaves of the *Elatocladus* type, pollen cones with *Podocarpidites* pollen; Archangelsky & Del Fueyo, 2010.

Phyllocladoxylon-Late Cretaceous (late Maastrichtian), mid-early Paleocene, lower middle Eocene, Antarctic Peninsula, wood; Poole et al., 2005.

Phyllocladites mawsonii- Late Cretaceous (late Maastrichtian), mid-early Paleocene, lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005. Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Podocarpidites marwickii- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012; *P.* sp.- Late Cretaceous (late Maastrichtian), lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005.

Podocarpoid wood type- Upper Cretaceous, Big Bend National Park, TX; Wheeler & Lehman, 2005.

Podocarpoxylon – Late Cretaceous (late Maastrichtian, wood, pollen), lower middle Eocene, middle Eocene, Antarctic Peninsula, leaf, wood; Poole et al., 2005.

Podocarpoxylon sp. 1- Cretaceous (mid-Aptian), Cerro Negro Fm., Byers Peninsula, Livingston Island, Antarctica, trunks, small stem; *P.* sp 2, op. cit., Falcon-Lang and Cantrill, 2001.

Podocarpus dacryidioides-mid-early Paleocene, lower middle Eocene, Antarctic Peninsula, pollen, Poole et al., 2005. *P. mazzonii*- early Paleocene (Danian, 61.7 ±0.2 Ma), Salamanca Fm., Province of Chubut, Argentina, wood; Brea et al., 2011. *Podocarpus* sp.- Eocene, western TN, leafy shoots, Dilcher, 1969; late Miocene, Upper Beluga Fm., south coast Alaska (with *Podocarpidites*), pollen, Reinink-Smith & Leopold, 2005; Pliocene-Quaternary (ca. 2.7 Ma), High Plain Bogotá, Colombia, pollen, Hooghiemstra, 1995. *P. matudae* (modern, as a possible pre-Quaternary relict), two plastid DNA markers suggest a divergence time between the unique haplotypes

from a Guatemalan population and the two most common haplotypes from the Sierra Madre Oriental in Mexico of between 10 and 20 Ma, and further haplotype divergence in the poorly resolved clade of the Sierra Madre Oriental between 3 and 0.5 Ma; findings support a Miocene age for temperate floristic elements in Mesoamericana cloud forests, whereas further haplotype divergence within the Sierra Madre Oriental, Chiapas and Guatemala occurred more recently, coinciding with Pleistocene cloud forest refugia (Ornelas et al., 2010).

Retrophyllum spiralifolium- early Eocene, La Huitrera Fm., foliage, peduncle, pollen cones, Chubut Province, Patagonia, Argentina; *R. supestes*- Cretaceous, terminal Maestrichtian, Lefipán Fm., leafy twigs; (R. *araucoensis* (Berry) comb. nov. stabilizes he nomenclature for the Chilean fossils). Wilf et al., 2017.

Saxegothaea conspicua- last interglacial (MIS 5e- called Valdivia in southern Chile), Mancera interglacial sequence, Mancera Island, Chile, wood, leaves; Astorga & Pino, 2011.

Squamastrobus- Early Cretaceous, Argentina, Patagonia, leaves of the *Brachyphylllum* type, pollen cones with *Podocarpidites* pollen, ovuliferous cones; Archangelsky & Del Fueyo, 2010.

Trisaccites microsaccatum- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Trisacocladus- Early Cretaceous, Argentina, Patagonia, twigs, leaves, pollen cones with *Trisaccites* pollen, ovuliferous cones with seeds; Archangelsky & Del Fueyo, 2010.

SCIADOPITYACEAE

Sciadopitipollenites- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et

al., 2011.

Sciadopitys- late middle to early late Miocene, Bryn Mawr Fm., MD, pollen; Pazzaglia et al., 1997. cf. *Sciadopitys*- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

TAXACEAE

Amentotaxus-type- middle Eocene, Republic Fl., WA; Schorn & Wehr, 1996. cf. *Amentotaxus*/cf. *Torreya*- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, leafy twigs, foliage; Dillhoff et al., 2005.

Diploporus torreyoides- middle Eocene (44 Ma), Clarno Fm., OR, seed; Manchester, 1994. *D.* sp.- late Eocene (36 Ma), lower John Day Fm., OR, seed; Manchester & McIntosh, 2007: "First described from the middle Eocene Nut Beds locality, *Diploporus* is also known from the Paleocene of Almont, ND (Pigg and Manchester, unpublished data" p. 8); also Beicegel Fl., ND, Pigg & DeVore, 2010; Crane et al., 1990.

Taxus masonii- middle Eocene (44 Ma), Clarno Fm., OR, seeds; Manchester, 1994. *T.*- type, middle Eocene, Republic Fl., WA; Schorn & Wehr, 1996.

Torreya clarnensis- middle Eocene (44 Ma), Clarno Fm., OR, seeds; Manchester, 1994. *T. masonii*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997. *T.* sp.- late Paleocene, Almont Fl., ND, seeds, Pigg & DeVore, 2010 (pers. comm. from Manchester); middle Eocene, Republic Fl., WA; Schorn & Wehr, 1996.

TAXODIACEAE (see also Cupressaceae)

Athrotaxopsis sp.- Lower Cretaceous (upper Albian), Potomac Group, VA, terminal

shoot with seed cone; Upchurch et al., 1994.

Cyptomeria anglica- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007.

Inaperturopollenites sp. (cf. *Sequoia*)- Miocene, Tepoztlán Fm., Mexico; Lenhardt et al., 2013.

Sphenolepsis sternbergina- Lower Cretaceous (upper Albian), Potomac Group, VA, shoots with attached seed and pollen cones; Upchurch et al., 1994.

cf. *Parataxodium*- Paleocene, Sentinel Butte Fm., Almont, Beicegel, ND, leafy shoots, ovulate and pollen cones, seeds; Crane et al., 1990; Pigg & DeVore, 2010.

Taxodiaceaepollenites hiatus- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Taxodium dubium- Oligocene (30.7 Ma), Haynes Creek Fl., ID, branchlets; Axelrod, 1998a. *T. olrikii*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Ludlow Member, Fort Union Fm., ND, SD, megaflora, Johnson, 2002.

WELWITSCHIACEAE

Cratonia cotyledon- Early Cretaceous (late Aptian), Crato Fm., Brazil; Rydin et al., 2003.

Welwitschiella austroamericana- stems with attached paired leaves, *Welwitschiophyllum brasiliense*- isolated leaves, *Welwitschiostrobus murili*- axes bearing male cones, Early Cretaceous (late Aptian), Crato Fm., Brazil; Dilcher et al., 2005.

WELSITSCHIOID

Bicatia- Friis, E. M. et al., 2014, p. 175: "*Bicatia* gen et sp. nov. from the Early Cretaceous of the Northern Hemisphere is described based on three species of dispersed seeds: *Bicatia costata* from the Juncal and Famalicão localities (western Portugal) and

Kenilworth locality (eastern North America), *B. juncalensis* from the Juncal locality, and *B. rugosa* from the Puddledock locality (eastern North America). The combination of seed and pollen features seen in *Bacatia* provides the strongest documentation so far of *Welwitschia*-like plants in the Northern Hemisphere during the Early Cretaceous."

WILLIAMSONIACEAE

Williamsonia bockii- Late Cretaceous (lower Campanian), Haslam Fm., Nanaimo Basin, Vancouver Is., Bristish Columbia, Canada, seed cone; Stockey & Rothwell, 2003.

INCERTAE SEDIS (Gymnospermae)

Lindlleycladus sp.- Lower Cretaceous, Crato Fm., Brazil; Kunzmann et al., 2004.

ANGIOSPERMAE

General summaries (see also Monocotyledons)

Angiosperm microfossils from the Late Cretaceous (Campanian) to Paleocene of Seymour Island, Antarctica (Askin, 1989) identified by a morphological system necessitated by the age of the deposits include (pp. 114-116) *Bombacacidites bombaxoides* (Bombacaceae), *Nothofagus* (Fagaceae), *Cranwellia striata* (Loranthaceae), *Anacolosidites sectus* (Olacaceae), *Proteacidites, Propylipollis, Cranwellipollis, Beaupreaidites verrucosus, B. elegansiformis, Peninsulapollis* (Proteaceae), *Cupanieidites orthoteichus* (Sapiindaceae), and *Polycolpites langstonii* (Pedaliaceae?).

Martínez-Millán (2010)- Asteridae, four main clades (Cornales, Ericales, Lamiids, and Campanulids; last two collectively the Euasteridae). "The results suggest that the Asteridae dates back to at least the Turonian, Late Cretaceous (89.3 mya) and that by the Late Santonian-Early Campanian (83.5 mya) its four main clades were already represented in the fossil record" (p. 83). Friis et al. (2006): "ANITA grade angiosperms

[= ***A****mborella,* **N**ymphaeales, **I**lliciaceae, **T**rimeniaceae, **A**ustrobaileyaceae] and Chloranthaceae, as well as other magnoliids, early monocots and early eudicots, differentiated almost simultaneously during the Early Cretaceous. There is also strong evidence for extensive diversification of core eudicots during the Late Cretaceous" (p. 251).

Wang et al. (2009): "The rosid clade diversified rapidly into these major lineages, possibly over a period of <15 million years, and perhaps in as little as 4 to 5 million years. The timing of the inferred rapid radiation of rosids [108 to 91 million years ago (Mya) and 107-83 Mya for Fabidae and Malvidae, respectively] corresponds with the rapid rise of the angiosperm-dominated forests and the concomitant diversification of other clades that inhabit these forests, including amphibians, ants, placental mammals, and ferns" (p. 3853).

Sun et al. (2011), re *Leefructus mirus*: "…morphological features suggest that its affinities are with the Ranunculaceae, a basal eudicot family. The fossil co-occurs with *Archaefructus sinensis* and *Hyrcantha decussate* whereas *Archaefructus liaoningensis* comes from more ancient sediments. Multiple radiometric dates of the Lower Cretaceous Yixian Formation place the bed yielding this fossil at 122.6-125.8 million years old. The earliest fossil records of eudicots are 127 to 125 million years old, on the basis of pollen. Thus, *Leefructus* gen nov. suggests that the basal eudicots were already present and diverse by the latest Barremian and earliest Aptian" (p. 625; see also Ranunculaceae).

McInnes et al. (2011): "Pulses of diversification are only detected easily if they occurred recently and if the rate of species turnover at equilibrium is low; rates reported for fossil mammals suggest that the power to detect a doubling of species diversity falls

to 50 per cent after less than 50 Myr even with a perfect phlogeny of extant species. Extinction does eventually draw a veil over past dynamics, suggesting that some questions are beyond the limits of inference, but sudden clade-wide pulses of speciation can be detected after many millions of years, even when overall diversity is constrained. Applying our methods to existing phylogenies of mammals and angiosperms identifies intervals of elevated diversification in each" (p. 3294).

INCERTAE SEDIS (Angiospermae; see also early undescribed angiosperms from the Lower Cretaceous Crato Formation, Brazil, Mohr & Friis, 2000, Mohr et seq.).

Archaeanthus Dilcher & Crane (1984)- mid-Cretaceous (uppermost Albian-mid-Cenomanian), Dakota Fm., KS, fruit (and associated perianth parts); Dilcher & Crane (1984).

Archaefructus liaoningensis (Archaefructaceae)- Yixian Fm., China [originally considered Jurassic in age, now mid-Early Cretaceous, Friis et al., 2006, p. 256]; Sun et al. (1998, 2002).

Carpolithus sp. 12- middle Eocene (44 Ma), Clarno Fm., OR, capsule; Manchester, 1994. [Meliaceae, either in *Toonia* or *Cedrela*; Steven Manchester, pers. comm., April, 2011].

C. sp.- late Eocene, Tonosi Fl., Pacific coast central Panama, disseminule; Herrera et al., 2012.

Ferrignocarpus bivalvis (= *Carpolithus* sp. 38 of Reid and Chandler, 1933), middle Eocene (44 Ma), Clarno Fm., OR, fruit; Manchester, 1994 "belongs in Fagales near or in Ticodendraceae (see Manchester & Renner Abstract, IBC Vienna)" Manchester, pers. comm., April, 2011.

Iara Iguassu (aquatic angiosperm)- Lower Cretaceous, Santana Fm. (Crato palaeoflora),

Araripe Basin, NE Brazil, filamentous stem, leaves; Fanton et al., 2006.

Kachaikenia compuesta- late Early Cretaceous, Kachaike Fm., So. Argentina, leaves; Cunéo & Gandolfo, 2005.

Laculifructus tonosiense- late Eocene, Tonosi Fl., Pacific coast central Panama, fruit; Herrera et al., 2012

Lagokarpos lacustris- latest Paleocene to early middle Eocene, Green River Fm. (WY, UT, CO, OR, British Columbia, Canada), Ulrich's Quarry near Fossil Butte National Monument, southwestern WY, winged fruits; McMurran & Manchester, 2010: "No modern fruit was found to exhibit the combination of characters seen in *Lagokarpos*, and we conclude that it represents an extinct genus of as yet unknown familial affinity" (p. 227).

Metacalfeoxylon kirtlandense (Malvids-Eurosids II)- Late Cretaceous (Maastrichtian), Crevasse Canyon Fm., NM, wood; Estrada-Ruiz et al., 2012.

Noferinia fusicarpa- Late Cretaceous (Santonian), GA, flower; Lupia et al., 2002.

Ozakia emryi ("…formerly attributed to *Heptacadium* (Caprifoliaceae) and *Amelanchier* (Rosaceae)…" now "…considered to represent an extinct eudicot genus…", Manchester and Uemure, 2013).

Paraphyllanthoxylon cf. *P. anazasii* (Magnoliids, or Eudicots probably Lauraceae)- Late Cretaceous (Maastrichtian), Crevasse Canyon Fm., NM, wood; Estrada-Ruiz et al., 2012.

Pygmaeoxylon paucipora (Magnoliid clade)- Late Cretaceous (Maastrichtian), McRae Fm., NM, wood; Estrada-Ruiz et al., 2012.

Rogersia australis- late Early Cretaceous, Kachaike Fm., So. Argentina, leaves; Cunéo &

Gandolfo, 2005.

Thorphyllum cúneo- late Early Cretaceous, Kachaike Fm., So. Argentina, leaves; Cunéo & Gandolfo, 2005.

Trapago angulata- Upper Cretaceous (Maastrichtian), St. Mary River Fm., Alberta, Canada, leaves, rhizomes, flowers; Stockey & Rothwell (1997): ["Although *Trapago* has commonly been placed in the Trapaceae, the similarities between extant *Trapa* and *Trapago* could be attributed to convergence, and the familial affinities of the fossil remain uncertain" p. 83].

Tripartisemen bonesii- middle Eocene (44 Ma), Clarno Fm., OR, seed; Manchester, 1994 now *Toricellia bonesii* (Toricelliaceae; Steven Manchester, pers. comm., April, 2011).

ACANTHACEAE- "We demonstrate differences in age estimates depending on fossil selection, and that enforcement of maximum age priors substantially alters estimated clade ages… Our results suggest that long-distance dispersal events explain present-day distributions better than do Gondwanan or northern land bridge hypotheses.. Our data support a minimum of 13 Old World (OW) to New World (NW) dispersal events but, intriguingly, only one in the reverse direction. Remarkably, if minimum age estimates approximate true history…11 of these 13 events occurred within the past ~20 Myr even though Acanthaceae s.s. is over 3 times as old. Finally, we review reports of fossils that have been assigned to Acanthaceae that are substantially older than the lower Cretaceous estimate for Angiosperms as a whole…" (Tripp and McDade, 2014, p. 660).

ACERACEAE (see Sapindaceae)

ACTINIDIACEAE

Actinidia oregonensis- middle Eocene (44 Ma), Clarno Fm., OR, seed; Manchester, 1994.

Parasaurauia allonensis- Late Cretaceous (late Santonian), Buffalo Creek Member, Gaillard Fm., Allon Fl., GA, flowers; Herendeen et al., 1999.

cf. *Saurauia*- late Paleocene, Almont, Beicegel Fls., ND, seeds, fruits, Crane et al., 1990; Pigg & DeVore, 2003, 2010.

ADOXACEAE

cf. *Rousea patagonica*- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Sambucus sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaf, leaflets; Manchester, 2001.

ALANGIACEAE (see Cornaceae)

ALISMATACEAE

Alismaphyllites grandifolius- late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada; Hoffman & Stockey, 1999.

Caldesia brandoniana- early Miocene, Brandon Lignite Fl., VT, fruits; Haggard & Tiffney, 1997.

Sagittaria sp.- late Miocene (Clarendonian, 12 Ma), Ironside Fm., OR; Retallack, 2004.

ALTINGIACEAE

Liquidambar sp.- middle Eocene, Claiborne Group, TN, fruit, Dilcher & Lott, 2005; middle Eocene, Republic Fl., WA, seeds, Wehr & Manchester, 1996; Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf, Meyer & Manchester, 1997; late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997.

L. or *Altingia*- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005. Late Miocene, Vasa Park Fl., King Co., WA, pollen; Dillhoff

et al., 2014.

AMARANTHACEAE (see also Chenopodiaceae/Amaranthaceae)

Chenopodipollis sp. (cf. *Iresine*)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

'AMENTIFERAE'- Crepet, 1981.

ANACARDIACEAE- [records of fossils from Germany and elsewhere are reviewed by Manchester et al., 2007].

Anacardiaceae- late Eocene (36 Ma), lower John Day Fm., OR, fruit; Manchester & McIntosh, 2007.

cf. *Anacardium*- middle Miocene, Pebas Fm., w. Amazon Basin, Iquitos, Peru, wood; Pons & de Franceschi, 2007.

Astronium-type pollen- latest Eocene (34.1 Ma), Florissant Fl., CO; Leopold & Clay-Poole, 2001.

Dracontomelon macdonaldii- late Eocene, Tonosi Fl., Pacific coast central Panama, endocarp; Herrera et al., 2012.

Edenoxylon parviareolatum- late early Eocene (ca. 49 Ma), Bridger Fm., Big Sandy Reservoir, SW Wyoming, wood; Bounchai & Manchester, 2012.

Loxopterygium laplayense- middle Miocene (13.0-10.2 Ma), Azogues or Guapá member, Azogues Fm., near Azogues, Ecuador; Siltstone Member, (10.7 +/- 1.6 to 10.0 +/- 1.4 Ma), San Cayetano Fm., Loja Basin, Ecuador; winged fruits; Burnham & Carranco, 2004.

Maureroxylon crystalliphorum- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Pentoperculum minimum- middle Eocene (44 Ma), Clarno Fm., OR, fruits; Manchester, 1994.

Pseudosmodingium mirandae- Oligocene, Pie de Vaca Fm., near Tepexi de Rodríguez, Puebla state, Mexico, leaves; Ramírez et al., 2000.

Rhus lesquereuxii (leaf), *R.* sp. (fruit)- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fm., OR; Meyer & Manchester, 1997. *R. malloryi*- middle Eocene, Republic Fl., WA, leaves; Wolfe & Wehr, 1987. *R. rooseae*- middle Eocene (44 Ma), Clarno Fm., OR, fruit; Manchester, 1994. *R. sonorensis*- middle Miocene, Mint Canyon Fl., (preliminary study), so. CA; Axelrod, 1940. *R.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, Manchester, 2001; Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO, leaves, Gregory & McIntosh, 1996. *R.* type- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Schinus- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

Tapirira clarnonensis- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Terrazoxylon ductifera- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Toxicodendron wolfei- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaflet; Meyer & Manchester, 1997.

ANNONACEAE (Richardson et al., 2004).

Annona- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

Annonoxylon bonesii- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Anonaspermum cf. *pulchrum, A. bonesii, A. rotundum*- middle Eocene , Clarno Fm., OR, seeds; Manchester, 1994.

Duguetia sp.- middle Eocene, Claiborne Group, TN, leaves; Dilcher & Lott, 2005.

Guatteria- Erkens et al. (2007) infer from four plastid regions (*matK. rbcL, trnL-trnF, psbA-trnH*) "three major biogeographical events in the history of the genus: (1) a trans-oceanic Miocene migration from Central into South America before the closing of the Isthmus of Panama; (2) a major diversification of the lineage within South America; and (3) several migrations of South American lineages back into Central America via the closed Panamanian land bridge. Therefore, *Guatteria* is not an Amazonian centered-genus *sensu* Gentry but a major Miocene diversification that followed its dispersal into South America" (p. 399). The authors state (p. 404) that there are no known fossils of the genus, but in addition to *Guatteria*-type phytoliths reported from the Quaternary of Central America, macrofossils (*G. culebrensis*) are reported from the Miocene of Panama and Peru (unverified; for additional reports of Annonaceae and for references, see Graham, 2010, Appendix 2.2, p. 588).

APIACEAE [Apiales- Nicholas and Plunkett, 2014: "Our analyses in BEAST estimated the origin of Apiales to Australasia, with the youngest family (Apiaceae) originating in the Late Cretaceous, c. 87 Ma. Long-distance dispersal appears as the likely explanation for many younger lineages within major clades…" (p. 30)].

Azorella, Laretia, and *Mulinum*- Nicolas and Plunkett, 2012: "Biogeographic reconstructions, conducted using RASP, suggest that the group most likely has an Austral-Antarctic origin, with subantarctic South America as the ancestral area of the ingroup. The "*Mulinum* clade" and the "*Schizeilema* clade" appeared to have followed

opposite dispersal routes out of subantarctic South America either across the Subantarctics into New Zealand and Australia ("*Schizeilema* clade"), or into Patagonia and then to the upper Andes ("*Mulinum* clade") (p. 826) … Due to the lack of fossils, we were unable to produce reliable estimates for times of divergence in the group, and therefore estimated historical biogeogaphic reconstructions using the statistical dispersal-vicariance method in RASP v.1.107 (Yu & al., 2011), which does not require timing estimates" (p. 830).

Carpites ulmiformis- Late Cretaceous (Maastrichtian), Lance Fm., WY, MT, seeds; Manchester & O'Leary, 2010: ["Compressed fruits of *Carpites ulmiformis* Dorf (1942)…are likely to represent Apiaceae", p. 63].

APOCYNACEAE

Apocynophyllum sp.- middle Eocene, Claiborne Group, TN, leaves; Dilcher & Lott, 2005.

Apocynospermum sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, seeds; Manchester, 2001.

Asclepias- Fishbein et al., 2011: "Our results support a scenario in which *Ascelpias* s.l. originated in Africa, migrated only once to North America, and thence only once to South America… times are difficult to ascertain in the absence of fossil calibrations for molecular dating…argues against Gondwanan disjunction and against frequent dispersal between these centers of diversity…consistent with Africa to America migration via either the North Atlantic or Bering land bridges or via long-distance transoceanic dispersal. Until recently, the possibility of range expansion of temperate or subtropical taxa through the North Atlantic route was thought to have ended in the early Eocene (Tiffney 1985). The timing (40-50 my before present) could be too early for the

migration of *Asclepias* to the Americas. However, recent paleobotanical discoveries and dated phylogenies for several groups have increasingly supported the hypothesis that range expansion across the North Atlantic may have been possible until the mid-Miocene or even later (Tiffney, 2008). Because recent long-distance dispersal could have occurred at any time, it must be considered as an alternative hypothesis, especially if the time of origin of the American-African disjunction is found to be too recent for migration over Tertiary land bridges" (p. 1016). [Author assessment: The transitory physical disruption of the North Atlantic land bridge reached a point by the middle Eocene that continuous or near-continuous land surfaces were significantly diminished. The transitory change in climate in the high latitudes from subtropical/warm temperate to more cool/cold temperate also reached a point at about this time when migration of the former diminished and migration of the latter was enhanced. Superimposed on these gradual and fluid conditions are the variables of dispersability and the ecological characteristics of the specific taxon under consideration. Thus, whether range expansion across the North Atlantic ended in the early Eocene, or was possible until the mid-Miocene or even later is decidedly taxon-dependent. As a generalization, the tipping-interval for the North Atlantic land bridge as a migration route from being widely available to more selective began in about the middle Eocene].

Tabernaemontana sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

Triporopollenites sp. 2- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Tylophora and *Vincetoxicum*- Liede-Schumann et al., 2012: "The early branching clades of *Vincetoxicum* s.l. all grow in Africa, where the group originated ca. 18 Ma ago,

correlating with the closure of the Tethys Ocean. The first round of differentiation took place between 12 and 15 Ma ago, resulting in Tylophorinae being distributed over almost all of their present range except for South Africa, Arabia and Europe. Two unrelated lineages of temperate, mostly erect plants hitherto named "Vincetoxicum" have arisen from more tropical lineages, hitherto named "Tylophora". One clade of African species is nested inside the Australasian assemblage; this clade contains exclusively polyploid species and its re-immigration to Africa took place in the Messinian, at ca. 6.8 Ma. The European *Vincetoxicum* species split from erect steppe plants of temperate Asia at ca. 4.5 Ma, coinciding with the uplift of the Tibetan plateau. This group contains two species that are presently aggressively spreading in North America after chance introductions" (p. 803).

AQUIFOLIACEAE

Ilex- late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997; Late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014; Pliocene-Quaternary (ca. 2.7 Ma), High Plain Bogotá, Colombia, pollen, Hooghiemstra, 1995. For a review of the 'complex history of *Ilex* from plastid-nuclear DNA sequences/fossil data' see Manea et al., 2002.

Ilexpollenites- Late Cretaceous (late Maastrichtian), lower middle Eocene, Antarctic Peninsula, pollen, Poole et al., 2005. cf. *Ilexpollenites* sp., Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Nemopanthus- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

ARACEAE- "Araceae began to diversify in the Early Cretaceous (when the breakup of Pangea was in its final stages), and all eight subfamilies existed before the K/T boundary. Early lineages persist in Laurasia, with several relatively recent entries into Africa, South America, South-East Asia and Australia" (Nauheimer et al., 2012).

Cobbania corrugata- Upper Cretaceous, Dinosaur Park Fm., Alberta, Canada, stems, attached leaves and roots interconnected by stolons; Stockey et al., 2007: ["We develop a reconstruction of the plant based on attached organs and compare the fossils with the fossil *Limnobiophyllum* and extant *Pistia*, revealing a greater systematic and ecological diversity of Late Cretaceous Araceae than previously recognized" (p. 609).

Keratosperma allenbyense- middle Eocene, Allenby Fm., Princeton Chert, near Allenby, British Columbia, Canada, seeds; Smith & Stockey, 2003: ["…represents the oldest known member of the lasioid clade" (p. 239)].

cf. *Lemnospermum* sp.- late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada; Hoffman & Stockey, 1999.

Limnobiophyllum scutatum- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora, Johnson, 2002; late Paleocene Joffre Bridge Fl., Red Deer Valley, Alberta, Canada; Hoffman & Stockey, 1999.

Lysichiton- Nie et al., 2006.

Montrichardia aquatica-middle to late Paleocene, Cerrejó Fm., 60-58 Ma, Colombia, leaf; Herrera et al., 2008 (extant genus, report is first fossil record).

Orontium- Nie et al., 2006.

Petrocardium wayuuorum - middle to late Paleocene Cerrejón Fm., Colombia, leaf. *P.*

cerrejonens, op. cit. Herrera et al., 2008. (new morphotype genus with two species both close in leaf morphology to extant neotropical genus *Anthurium*).

Philodendron limnestis- Eocene, Claiborne Fm., TN, leaves; Dilcher & Daghlian, 1977.

aff. *Philodendron*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

"*Pistia*" *corrugata*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Spixiarum kipea gen et sp. nov.- Early Cretaceous, Crato Fm., northeastern Brazil; Coiffard et al., 2013.

Symplocarpus- Nie et al, 2004.

ARALIACEAE (see also Rutaceae-*Rhiopites*)

Araliaceous fruits- latest Eocene (34.1 Ma), Florissant Fl., CO; Manchester, 2001.

cf. *Aralia* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage; Dillhoff et al., 2005.

Aralia- Wen, 2011.

Dendropanax- Li & Wen (2013): "Based on biogeographic analyses and fossil-calibrated Bayesian dating, *Dendropanax* was hypothesized to have originated in the Old World and migrated into the New World via the North Atlantic land bridge in the early Tertiary. The amphi-Pacific intercontinental disjunction of *Dendropanax* was dated to be 41.83 mya with a 95% high posterior density [HPD] interval of 28.46-56.15 mya" (p. 536). *D. eocenensis*- middle Eocene, Claiborne Group, TN, leaves; Dilcher & Dolph, 1970; Dilcher & Lott, 2005.

Hedera- Green et al. (2011): " Reports of *Hedera* from the Dakota Formation and other

North American sites are almost certainly invalid…Among verified fossils nearly all specimens were collected from Europe and Asia" [Green et al., 2011 list several Old World occurrences dating from the late Miocene to the Holocene, p. 1124).

Paleopanax oregonensis- middle Eocene (44 Ma), Clarno Fm., OR, fruit, styles; Manchester, 1994. cf. *Paleopanax*- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, fruits; Dillhoff et al. 2005.

Plerandreoxylon nutbedensis, P. oregonensis- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Toricellia sp.- Late Paleocene, Almont Fl., ND, fruit; Manchester et al., 2009; Pigg & DeVore, 2010.

ARECACEAE (early records New World and outside the New World: "The earliest unequivocal fossil palm material probably dates from the early to mid Late Cretaceous (Turonian > Coniacian > Santonian"; Harley, 2006, p. 39). Areaceae pollen- latest Eocene (34.1 Ma), Florissant Fl., CO; Leopold & Clay-Poole, 2001. See also Baker and Couvreur, 2013. Nomenclature (conservation of *Palmoxylon*, see Doweld, 2017).

According to Couvreu et al. (2011), diversification of extant lineages of palms started during the mid-Cretaceous period about 100 million years ago in a tropical rain forest-like environment at northern latitudes, and "conform to a constant diversification model…at least until the Neogene, with no evidence for any change in diversification rates even through the Cretaceous/Paleogene mass extinction event. In contrast to other plant studies, our results suggest that ancient and steady evolutionary processes dating back to the mid-Cretaceous period can contribute, at least in part, to present day species richness" (9:44).

?Palmae (Arecaceae)- *Ailanthipites, Arecipites, Ericipites, Gemmamonocolpites pilulus, Polycolpites* cf. *langstonii, Retistephanocolporites* sp. A, *Stellidiopollis annulatus, Triporopollenites*- Late Cretaceous (late Maastrichtian), Antarctic Peninsula, pollen; Poole et al., 2005.

Amesoneuron and/or *Sabalites*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora; Johnson, 2002.

Astrocaryum- Roncal et al. (2013): "Cladogenesis of Western Amazonian *Astrocaryum* spp. (*c*. 6 Ma) post-dated the drainage of the aquatic Pebas system…The ancestral distribution of *Astrocaryum* spp. in the Guiana Shield supported the hypothesis of an old formation that acted as a source area from which species colonized adjacent regions, but an earliest branching position for Guianan species was not confidently recovered. A twofold increase in diversification rate was found in a clade, the ancestor of which occupied the Guiana Shield (*c*. 13 Mya, a time of climatic change and Andean uplift)" (p. 120).

Bactridinae- ["Bactridinae include about 150 species of spiny Neotropical palms in five genera that are ecologically important in several vegetation types such as open woodland (*Acrocomia*), lowland rainforest (*Astrocaryum, Bactris*), and montane forest (*Aiphanes*). A Bayesian dating analysis using the relaxed-clock model indicates that most genera of the Bactridinae diverged during a relatively short period around the Eocene-Oligocene boundary, which might explain the difficulties in resolving the phylogenetic backbone of the group. The most Andean genus *Aiphanes* shows an initial radiation of early lineages in the Oligocene (around 25 Ma ago) corresponding to

an early uplift phase of the cordillera. These taxa are now restricted to the mountain forests of Columbia and Ecuador. The main diversification of Andean *Aiphanes* began in the Miocene (around 11 Ma ago)" Eiserhardt et al., 2011, p. 485].

Ceroxyloideae (wax palm subfamily)- disjunct distribution (Caribbean lineage, Southern Hemisphere disjunction, amphi-Andean element) based on DNA sequences from three plastid and two nuclear genomic regions was due to mid-Tertiary dispersal with radiation coinciding largely with the major uplift of the Andes (Trénel et al., 2007).

cf. *Cocos* sp.- middle to late Paleocene, Cerrejón Fm., Ranchería River Valley, northern Colombia, fruits; Gomez-Navarro et al., 2009; also reported are fossil Arecoideae inflorescences; fossil Arecaceae sp. 1 (fragments of pinnate leaves), fossil Arecaceae sp. 2 (fragments of costapalmate or palmate leaves).

Gemmamonocolpites (Araceae?)- lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005.

Gemmamonocolpites pilulus (?Arecaceae)- mid-early Paleocene, Antarctic Peninsula, pollen; Poole et al., 2005.

Grimsdalea magnaclavata- "Based on the new observations of the pollen morphology we conclude that the records from Cretaceous and Paleogene sediments in North and West Aftica are invalid. *G. magnaclavata* is clearly restricted to northern South America from the Miocene to Pleistocene. The parent plant…probably grew in upper coastal plain or around swamps…nearest living relatives are the genera *Mauritia* and *Mauritiella*" (Pocknall and Jarzen, 2012, p. 1).

Monocolpopollenites sp. 2- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Nypa sp.- middle to late Paleocene, Cerrejón Fm., Ranchería River Valley, northern Colombia, fruits; Gomez-Navarro et al., 2009. Middle Eocene, Laredo Fm., Webb Co., TX, pollen (*Spinozonocolpites prominatus*); Westgate & Gee [1990: "Fossil *Nypa* pollen, described under the form genus name *Spinozonocolpites*, has a fossil record extending from the Late Cretaceous to the Recent (Frederiksen, 1985; Thanikaimoni, 1987", p. 171].

Palmacites sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaf; Manchester, 2001.

Ruminosemen panamensis- late Eocene, Tonosi Fl., Pacific coast central Panama, seed; Herrera et al., 2012.

Sabal bracknellensis, S. jenkinsii- middle Eocene (44 Ma), Clarno Fm., OR, seeds; Manchester, 1994. *Sabal* sp.- late Eocene (36 Ma), lower John Day Fm., OR, seed casts; Manchester & McIntosh, 2007. (see also *Amesoneuron*).

Palmoxylon macginitiei- late early Eocene (ca. 49 Ma), Bridger Fm., Big Sandy Reservoir, SW Wyoming, wood; Bounchai & Manchester, 2012.

Socratea brownii (Iriarteinae: Arecoideae)- Oligo-Miocene, La Quinta Fm., Simojovel, Chiapas, Mexico, flowers; Poinar, 2002.

Spinozonocolpites- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Trithrinax dominicana (Thrinacinae: Coryphoideae)- Miocene, Dominican amber (mines, northern mountain ranges), flowers; Poinar, 2002.

ASTERACEAE- middle Eocene, Patagonia, capitulescence with long pedunculate capitula, pollen (cf. *Mutisiapollis telleriae,* Patagonia and *Tubuliforidites viteauensis*, Africa), Barreda et al., 2010a; Stuessy, 2010; see also Barreda et al., 2010b; Graham,

1996; Katinas et al., 2007; Zavada & de Villiers, 2000- *Tubuliforidites antipodica, T. viteauensis* (pollen) from the Paleocene-Eocene, South Africa. Numerous records Eocene onwards: Late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005. Late Miocene, Vasa Park Fl., King Co., WA, pollen; Dillhoff et al., 2014.

Subfamily Barnadesioideae- see *Tubulifloridites, Quillembaypollis*

Subfamily Carduoideae, Tribe Cardueae- Barres et al. (2013): "Tribe Cardueae is inferred to have originated around the Mid Eocene in West Africa, which is also the ancestral area of most subtribes within Cardueae. Diversification within each subtribe began during the Oligocene-Miocene period" (p. 867); "…new fossil evidence assigned to basal subfamilies (such asd Barnadesioideae) within Compositae (Barreda et al, 2010a,b)…" (p. 868); see also p. 872 (Age constraints and the fossil record; divergence times), p. 877 Historical biogeography of Cardueae; Origin in West Asia and Mediterranean diversification), p. 880 (Colonization of the New World).

Subfamily Cichorioideae, Tribe Liabeae- Funk et al. (2012): "The phylogeny slightly alters previous assumptions about the biogeography and it seems that Liabeae originated in the central and northern Andes and spread north and south with several independent introductions into Mexico and Central America and one into the Caribbean" (p. 437). See also Biogeography (pp. 450-452).

Artemisia (Anthemideae, subgenus *Seriphidium*)- see also Malik et al., 2017 (phylogeny and biogeography).

Artemisiapollenites sp. (*Artemesia*)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Compositoipollenites sp. 1- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Grindelia- Moore et al., 2012: There are two major clades of North American *Grindelia,* primarily east and west of the Rocky Mountains. "Given that the Rocky Mountains have been at approximately their current elevation since the end of the Laramide Orogeny in the Eocene…and that the origin of the asteroid tribes (including Astereae) has been dated to approximately 30 million years ago…, dispersal is more likely than vicariance to explain this distribution. In addition, the more northern taxa are nested well within the two clades, as would be expected from a pattern of colonization from the south, but not from a pattern of vicariance due to uplift of the Rocky Mountains" (p. 226).

Quillembaypollis gen. nov., Palazzesi et al., 2009; aff. Barnadesioideae). *Q. gamerroi*- early Miocene (23-20 Ma), Puerto Madryn Fm., ne Chubut Province, Patagonia, Argentina, pollen, aff. extant *Chuquiraga*, *Dasyphyllum, Schlechtendalia*; Palazzesi et al., 2009. *Q. tayuoides*- early Miocene (23-20 Ma), Chenque Fm., se Chubut Province, Argentina, aff. extant *Dasyphyllum*; Palazzesi et al., 2009. *Q. stuessyi*- late Miocene (11-9 Ma), Puerto Madryn Fm., ne Chubut Province, Argentina, aff. extant *Schlechtendalia*; Palazzesi et al., 2009.

Raiguenrayum cura- Eocene (47.5 Ma), Huitera Formation, northwestern Patagonia, Argentina, Río Negro Province, Estancia Don Hipólito locality, capitulescence; Barreda et al., 2012.

Tubilifloridites lilliei- late Cretaceous, Antarctica (76-66 Ma), pollen,extinct early – diverging clade of family (aff. cf. *Dasyphyllum*, subfamily Barnadesioideae;

'drastically pushes back the timing of assumed origin of the family'). Barreda et al., 2015.

ATHEROSPERMATACEAE

Atherospermophyllum (gen. nov.) , *A. guinazui* (Berry) comb. nov.- early Eocene (52.2 Ma.), Laguna del Hunco Fl., Chubut Province, Patagonia, Argentiana, leaves, cf. extant *Daphnnandra, Doryphora*); Knight and Wilf, 2013.

Atherospermoxylon- Late Cretaceous (Coniacian to Campanian), Late Cretaceous (late Maastrichtian), early-late Paleocene, lower middle Eocene, Antarctic Peninsula, wood, Poole et al., 2005.

Laurelites jamesrossii- Late Cretaceous (Coniacian to Campanian), Late Cretaceous (late Maastrichtian), mid-early Paleocene, middle Eocene, Antarctic Peninsula, wood, Poole et al., 2005.

AUCUBACEAE

Aucuba smileyi- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997.

BERBERIDACEAE

Berberis ahuehuetensis, B. lozanofolia, B. poblana, B. tepexiana- Oligocene, lowest member Pie de Vaca Fm., Los Ahuehuetes locality near Tepexi de Rodríguez, Puebla, Mexico, leaves; Ramírez & Cevallos-Ferriz, 2000. *B. hirsutus*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaf; Axelrod, 1998a. *B*. sp.- Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO, leaves; Gregory & McIntosh, 1996. *B. darwinii*- last interglacial (MIS 5e, called Valdivia in southern Chile), Mancera interglacial sequence, Mancera Island, Chile, leaves; Astorga & Pino, 2011.

Mahonia deweyensis, M. reticulata- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaflets; Axelrod, 1998. *M. creedensis*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaflet; Axelrod, 1998a. *M. grantiana, M. limirivuli*- Oligocene, Horse-Prairie Basin, southwestern MT, leaf; Becker, 1962. *M. lobodonta*- Oligocene, Ruby Fl., southwestern MT, leaf; Becker, 1959. *Mahonia martinezii*- Oligocene, lowermost member Pie de Vaca Fm., Los Ahuehuetes locality near Tepexi de Rodíguez, Puebla, Mexico, leaves; Ramírez & Cevallos-Ferriz, 2000. *M. simplex*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaflet, Axelrod, 1998a; Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf, Meyer & Manchester, 1997. *M.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaflets, Manchester, 2001; Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO, leaves, Gregory & McIntosh, 1996. *M. mohavensis*- middle Miocene, Mint Canyon Fl. (preliminary study), so. CA; Axelrod, 1940. *Mahonia/Berberis*- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

BETULACEAE- using ribosomal DNA sequences "we found that the age of the crown group and stem lineage of Betulaceae vary from 115.2 to 130.6 million years and 211.2 to 302.6 million years (Aptian or before). These results are older than current paleobotanical data. We calculated paleobotanical confidence intervals using methods based on the occurrence of fossils on a stratigraphic column and the lengths of the gaps between these occurrences. We apply these methods to the fossil record of *Alnus* and related extinct genera; however, only in some cases were molecular- and fossil-based estimates reconciled" (Forest et al., 2005, p. 118). The stem lineage may go back into the Late Cretaceous depending on the degree of affinity with the extinct Normapolles group.

See also Sims et al. (1999), 'higher' hamamelids (Juglandaceae, Rhiopteleaceae, Myricaceae, Betulaceae).

Alnipollenites scoticus, A. versus (*Alnus*)- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011. *A. versus* (*Alnus*)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, pollen; Daly et al., 2011. *A. versus* (*Alnus*)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Alnus- "The earliest records of the genus *Alnus*…are from the Paleocene of the Kenai Peninsula, Kachemak Bay, Alaska…(Hollick, 1936, p. 95), from the Middle Eocene of southern England (*Alnus poolensis* Chandler; Chandler 1963), from the Middle Eocene Clarno Formation of Oregon…, and from the Paleocene and Eocene of the USSR (*A. beringiana* Budantsev; Budantsev 1982)" (Crane & Stockey, 1987, p. 2498). *A.* subgenus *Alnus*- middle Eocene Clarno Fm., Oregon, leaves and associated catkins, pollen, and fruits, Liu et al., 2014; *A. cecropiifolia*, *A. gaudinii, A.* cf. *kefersteinii*- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. *A. fairii, A. hallii, A. latahensis, A. lemhiensis*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves, seed cones; Axelrod, 1998a. *A. heterodonta* (leaf), *A. newberryi* (leaf), *A.* sp. (leaves, infructescence, fruit, staminate catkins)- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR; Meyer & Manchester, 1997. *A. microdontoides*- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaves; Axelrod, 1998. *A. parvifolia*- middle Eocene, Republic Fl., WA, fruits, Wehr & Manchester, 1996; late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage, ovulate cones, *Alnus* pollen, *Alnus*, 2 sp., cones, Dillhoff et al., 2005. *A.* sp.- late Eocene (36 Ma), lower John Day Fm., OR, infructescences, Manchester & McIntosh, 2007; late middle to early late

Miocene, Byrn Mawr Fm., MD, pollen, Pazzaglia et al., 1997; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, leaves, pollen, Dillhoff et al., 2014.

Astrocarpinus perplexans- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, fruit; Meyer & Manchester, 1997. cf. *Asterocarpinus,* late Eocene (36 Ma), lower John Day Fm., OR, nuts; Manchester & McIntosh, 2007. *A.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, fruits; Manchester, 2001.

Bedellia pusilla- Late Cretaceous (late Santonian), Buffalo Creek Member, Gaillard Fm., Allon Fl., GA, staminate flowers; Herendeen et al., 1999.

Betula angustifolia- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf, bract, fruit; Meyer & Manchester, 1997. *B. cristata, B. islandica, B.* sect. *Costatae, B. subnivalis*- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. *B. clarnoensis*- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002. *B. leopoldae*- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage, aments, *Betula* pollen, Dilhoff et al., 2005; middle Eocene Republic Fl., WA, Wolfe & Wehr, 1987, Crane & Stockey, 1987; middle Eocene, Allenby Fm., Princeton, British Columbia, Canada; leaves, infructescenses, fruits, staminate inflorescences, pollen; Crane & Stockey, 1987: [The authors review the fossil record of the family, p. 2498]. *B. ashleyi, B. eoluminifera, B. lemhiensis*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves; Axelrod, 1998a. *B.* sp.- late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014.

aff. *Carpinus* sp., *C. perryae*- middle Eocene, Republic Fl., WA, infructesence, fruit, Wehr & Manchester, 1996, Pigg et al., 2003 *C.* sp.- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007.

Carpinus/Ostrya- late Miocene Fl., King Co., WA, pollen; Dillhoff et al., 2014.

Carpinidites sp. (*Carpinus* cf. *tropicalis* subsp. *mexicana*)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Corylites sp.- late Paleocene, Almont, Beicegel Fls., ND, leaves, Crane et al., 1990, Manchester et al., 2004, Pigg & DeVore, 2010.

aff. *Corylus* sp., *C.* sp.- Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora, Johnson, 2002; middle Eocene, Republic Fl., WA, fruit, Wehr & Manchester, 1996. cf. *Corylus* sp. (*Corylus*-type pollen)- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada; Dillhoff et al., 2005. *C. johnsoni*- middle Eocene, Republic Fl., WA, infructesence, fruit; Pigg et al., 2003. *C.* sp. 1, 2- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. *Corylus* and types- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Coryloides hancockii- middle Eocene (44 Ma), Clarno Fm., OR, nut; Manchester, 1994. *C.* sp.- late Eocene (36 Ma), lower John Day Fm., OR, nut; Manchester & McIntosh, 2007.

Cranea wyomingensis (Coryloideae)- Paleocene, Fort Union Fm., Wind River, Bighorn, and Powder River Basins, WY, and lower Eocene, Willwood Fm., Bighorn Basin, WY, infructescences, leaves, staminate inflorescences, pollen, Manchester & Chen, 1996, 1998; Pigg & DeVore, 2010.

Kardiasperma parvum- middle Eocene (44 Ma), Clarno Fm., OR, locule casts;

Manchester, 1994.

Ostrya oregoniana- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf, fruit; Meyer & Manchester, 1997. *Ostrya/Carpinus*-type pollen, latest Eocene (34.1 Ma), Florissant Fl., CO, Leopold & Clay-Poole, 2001; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005.

Palaeocarpinus aspinosa- Paleocene, Fort Union Fm., WY, infructescences, fruits, staminate inflorescences, leaves, pollen, Manchester & Chen, 1996, 1998; Bighorn, Green River Basins, Pigg & DeVore, 2010. *P. barksdalae*- middle Eocene, Republic Fl., WA, fruit; Pigg et al., 2003. *P. dakotensis* (Betulaceae: Coryloideae), late Paleocene, Sentinel Butte Fm., Almont and Beicegel Creek floras, ND, infructescences with associated staminate catkins, pollen, and leaves, Crane et al., 1990; Manchester et al., 2004; Pigg & DeVore, 2010. *P. joffrensis*- late Paleocene, Alberta Basin, Munce's Hill, Canada, Sun & Stockey, 1992; Pigg & DeVore, 2010; Stockey et al, 2014. *P.* sp.- middle Eocene, Republic Fl., WA, fruits; Wehr & Manchester, 1996.

Paracarpinus chaneyi- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997. *P.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaves; Manchester, 2001.

Triporopollenites coryloides ("Grains of this type were observed *in situ* by Manchester et al. (2004) in catkins associated with *Palaeocarpinus dakotensis*, a common plant at Almont. Pollen fitting this description also occurs in stamens of catkins associated with extinct betulaceous infructescences and fruits known as *Cranea* from the Paleocene of Wyoming … in Manchester and Chen, 1998)" (Zetter et al., 2011)- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011. Late Paleocene (~60 Ma),

Sagwon Bluffs, North Slope Alaska, pollen; Daly et al., 2011.

Trivestibulopollenites betuloides (*Betula* sp.)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

BIGNONIACEAE (family, middle Eocene, Republic Fl., WA, seeds; Wehr & Manchester, 1996; see also Solonaceae).

Bignonieae- "Two fossils identified as *Callichlamys* (Chaney and Sanborn, 1933) and *Paragonia/Arrabidaea*—currently *Tanaecium/Fridericia*—(Graham, 1985) were placed at nodes 32 and 102 of the resulting phylogeny, with estimated ages of 34.8 +/- 0.22 Myr and 35.35 +/- 1.65 Myr, respectively" (Alcantara & Lohmann, 2010, p. 3). "Our analyses suggest that the crown group of Bignonieae originated in South American rainforests approximately 50 Mya. Ancestral area reconstructions for the early divergences are equivocal, althought the resulting *Adenocalymma-Neojobertia* and core Bignonieae clades appear to have occurred in eastern South America and lowland Amazonia, respectively" (Lohmann et al., 2013, p. 154).

Adenocalymma- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

Catalpa hispaniolae- mid-Tertiary (20-15 Ma to 45-30 Ma), La Búcara Mine, northern mountain range (Cordillera Septentrional), Dominican republe between Puerto Plata and Santiago, flowers; Poinar, 2016.

Catalpa sp.- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek fl., OR, seed; Meyer & Manchester, 1997.

Lundia- Kaehler et al. (2012): "These results suggest that the genus may have originated in the western part of South America and subsequently occupied drier areas of central

Brazil and the humid forests of southeastern Brazil. However, this hypothesis remains to be tested with more robust analyses involving formal ancestral area reconstructions of the distribution of the various taxa, in combination with divergence-time estimates that would provide a temporal component for the interpretation of the distribution patterns within a geological framework (Kaehler & al., in prep.)" (p. 377).

BIXACEAE

Choclospermum (Choclospermaceae)- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

BOMBACACEAE

Bombacacidites bombaxoides- Late Cretaceous (late Maastrichtian), Antarctic Peninsula, pollen; Poole et al., 2005.

BORAGINACEAE (see also Heliotropiaceae)

Boragineae- "…there is a rich fossil record of putative Boraginaceae nutlets from the Miocene and Pliocene of North America (Gabel 1987; Gabel et al. 1998; Segal 1966; Thomasson 1977, 1979). Some can be assigned to the *Lithosermum*-species group of Lithospermeae (†*L. dakotense*; Gabel 1987; Gabel et al. 1998; Weigend et al. 2009), others to the Cynoglosseae (*Cryptantha* and †*Prolappula*; Segal 1966; Thomasson 1979). Three fossil taxa (†*Biorbia*, †*Eliasiana*, and †*Prolithospermum*) have been tentatively assigned to Borgineae (Thomasson, 1979), a group not at present native to North America" (Weigend et al., 2010, p. 409; see also pp. 416-417).

Cryptantha- Hasenstab-Lehman & Simpson, 2012: "Although sampling is incomplete, this study generally supports the hypothesis of repeated unidirectional dispersal events, from North to South America" (p. 738).

Tiquilia- combined sequence data from three chloroplast markers (*matK, ndhF,* and *rps 16*) and two nuclear markers (ITS and *waxy*) suggest "that the stem lineage of *Tiquilia* split from its nearest extant relative in the Paleocene or Eocene (~59-48 Ma). This was followed by a relatively long period before the first divergence in the crown group near the Eocene/Oligocene boundary (~33-29 Ma), shortly after the greatest Cenozoic episode of rapid aridification. Several major lineages show a marked increase in diversification concomitant with the onset of more widespread semi-arid and then arid conditions beginning in the late Miocene (~7 Ma). This sequence of divergence events in *Tiquilia* agrees well with earlier researchers' ideas concerning North American desert flora assembly" (Moore & Jansen, 2006, p. 668).

BRASSICACEAE (see Koch, 2012 for Old World, mid-Miocene (13.8 Ma) divergence of *Ionopsidium* and *Cochlearia* associated with the Messinian salinity crisis in the late Miocene).

Descurainia- Goodson et al. (2011): Old World origin with recent diversification within the Canary Islands and the New World…multiple independent dispersals between North and South America…As a calibration point the age of the node joining *Arabidopsis* to *Brassica* was fixed at 43. 2 myr (Beilstein et al., 2010). …origin of the Descurainieae 23.18 +/- 2.2 myr with the last common ancestor of Canary Island taxa arising 1.57 +/- 0.57 mya…last common ancestor of *Robeschia-Descurainia*, New World *Descurainia*, and Canary Island *Descurainia* as 22.45 +/- 1.41 mya, 5.20 +/- 5.20 mya, and 2.40 +/- 0.45 mya, respectively. Geographic expansion of *Descurainia* out of ancestral areas appears to have begun in the late Miocene with diversification accelerating during the late Pliocene or early Pleistocene. The ancestral species arrived

in the Canary Islands 1-2.8 mya, probably from the Iberian Peninsula…New World species of *Descurainia* are of Pliocene/early-Pleistocene origin, with molecular clock calculations from cpDNA data estimating a date of 4.7-5.7 myr for the last common ancestor of all New World taxa, and ITS data suggesting an origin of approximately two mya for each of the three major New World clades. The greater genetic diversity within North America relative to South America argues for North America as the continent of initial establishment, and is consistent with the general distribution pattern observed in New World Brassicaceae. Any introduction from Europe via a North Atlantic land bridge can be ruled out; such a land connection is believed to have been broken by the early Eocene (Tiffney 1985; Tiffney and Manchester 2001). [see *Asclepias*].

Thlapsi primaevum- early Oligocene, MT, fruit; Manchester & O'Leary, 2010: ["The observed features of fruit morphology are consistent with Brassicaceae, and the distinctive ornamentation of the seeds, taken along with the fruit characters, confirm Becker's [1961] assignment of this fossil to extant *Thlaspi*" p. 67].

Tricolpopollenites sp. 1 (cf. Brassicaceae)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013. *T.* sp. 4 (cf. Brasssicaceae, cf. Oleaceae)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

BROMELIACEAE- "Analyses based on *ndh*F sequence variation indicate that Rapateaceae and Bromeliaceae…underwent crown radiation around 41 and 23 Ma, respectively. Among bromeliads, *Pitcairnia feliciana*…appears to be the product of long-distance dispersal ca. 12 Ma…, the Guiana Shield was ...cradle of the bromeliads. Bromeliad acquisition of key adaptations to drought…17 Ma appears to have coincided

with and help cause the centripetal invasion of drier, more seasonal regions beyond the Guyana Shield…" (Givnish et al., 2004, p. 535).

"Bromelids arose in the Guyana Shield ca. 100 million years ago (Ma), spread centrifugally in the New World beginning ca. 16-13 Ma, and dispersed to West Africa ca. 9.3 Ma. Modern lineages began to diverge from each other roughly 19 Ma. Nearly two-thirds of extant bromeliads belong to two large radiations: the core tillandsioids, originating in the Andes ca. 14-2 Ma, and the Brazilian Shield bromelioids, originating in the Serro do Mar and adjacent regions ca. 9.1 Ma" (Givnish et al., 2011, p. 872).

Karatophyllum bromelioides- Middle Tertiary, Alajuela Province, Costa Rica, leaf impression; Baresch et al., 2011. [Noted previously in Graham, 2010, p. 333, 589].

Puya- Jabaily & Sytsma, 2013): The genus originated in central Chile and first moved into the Cordillera Oriental of the central Andes via inter-Andean valleys. Caldogenesis progressed in a general south to north direction tracking the final uplift of the Andes. Repeated evolutionary transitions of lineages up and down in elevation are suggestive of allopatric speciation driven by Pleistocene glaciation cycles" (p. 201).

BURSERACEAE- Based on nuclear and chloroplast data "Our data support a North American Paleocene origin for the Burseraceae followed by dispersal of ancestral lineages to eastern Laurasia and Southern Hemisphere continents" (Weeks et al., 2005, p. 85). "…the earliest known fossils attributable to the eudicotyledon lineage and the Sapindales date to ca. 125 Ma (Doyle and Hotton, 1991; Magallón et al., 1999) and ca. 65 Ma (Knobloch and Mai, 1986), respectively" (Weeks et al., 2005, p. 86).

Bursera- Becerra et al. (2012): "New calculations of the age of Burseraceae date the beginning of its diversification to at least 93 million years ago" (p. 333). See also

Divergence time estimation (pp. 335-336), Timing the divergence of Burseraceae (pp. 336-337), and Discussion (pp. 340-341).

Bursericarpum oregonense, B. sp.- middle Eocene (44 Ma), Clarno Fm., OR, fruits, Manchester, 1994; late Eocene (36 Ma), lower John Day Fm., OR, endocarps, locule casts, Manchester & McIntosh, 2007.

BUXACEAE

Erdtmanipollis cretaceous (*Pachysandra, Sarcococca*)- late Paleocene, Almont Fl., Williston Basin, pollen; Zetter et al., 2011.

CABOMBACEAE

Brasenites kansense (cf. Cabombaceae)- Lower Cretaceous (Albian), Dakota Fm., Hoisington III locality, Barton Co., KS, leaves; Wang & Dilcher, 2006.

Cabomba- late Miocene/Pliocene, Gatun Fm., Canal region, Panama, pollen; Graham 1991.

CACTACEAE

Harrisia- Franck et al., 2013: "Using the four-marker Bayesian tree, the r8s penalized likelihood analysis estimated the origin of *Harrisia* to be 3.45-6.53 Ma ago. The crown age of the first split within *Harrisia* was dated at 1.75-3.30 Ma ago. The crown age of the divergence between the Gran Chaco species and *H. tetracantha* was 0.69-1.30 Ma ago. Diversification of the Gran Chaco species was estimated at 0.20-0.38 Ma ago. The Caribbean species and *H. adscendens* had a divergence date of 0.81-1.53 Ma ago. The split between *H. earlei* and the rest of the Caribbean species was estimated at 0.24-0.45 Ma ago. The rest of the Caribbean species had a diversification date of 0.20-0.37 Ma ago" (pp. 212-216).

CALCEOLARIACEAE (see also Lamiales)

Jovellana- Nylinder et al. (2012): "…the presence of *Jovellana* in New Zealand is the result of long-distance dispersal across the Pacific Ocean from South America" (p. 381). The authors further review the fossil record and divergence times of the Calceolariaceae and related taxa (pp. 383-388).

CALOPHYLLACEAE

Mammean paramericana sp. nov.- fossil wood, Miocene, Panama, Nelson and Jud, 2017.

CAMPANULACEAE (biogeography, glacial refugia)- see Barnard-Kubow et al. (2015); Crowl et al., 2016.

CANELLACEAE

Wilsonoxylon edenense- late early Eocene (ca. 49 Ma), Bridger Fm., Big Sandy Reservoir, SW Wyoming, wood; Bounchai & Manchester, 2012.

CANNABACEAE (*Aphananthe, Celtis, Trema* formerly in Ulmaceae)

Aphananthe maii- middle Eocene (44 Ma), Clarno Fm., OR, endocarp, locule casts, Manchester, 1994; late Eocene (36 Ma), lower John Day Fm., OR, endocarp, Manchester & McIntosh, 2007. *A.* sp.- late Paleocene (Tiffanian), Paskapoo Fm., Alberta, Canada, leaves, Stockey et al, 2014.

Celtis aspera- late Paleocene, Bighorn Basin, WY; Manchester et al., 2002; Pigg & DeVore, 2010. *C. burnhamae, C.* sp.- middle Eocene (44 Ma), Clarno Fm., OR, endocarps; Manchester, 1994.

aff. *Humulus*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Trema nucilecta- middle Eocene (44 Ma), Clarno Fm., OR, endocarps, locule casts; Manchester, 1994.

CANELLACEAE (long-distance dispersal, New- Old World, nuclear gene/chloroplast loci; Müller et al., 2015.

CAPRIFOLIACEAE (see *Ozakia*, Angiospermae incertae sedis)

Diplodipelta reniptera- Oligocene (30.7 Ma), Haynes Creek Fl., ID, fruits; Axelrod, 1998a: "Many of the fossil fruits assigned earlier to *Pteleaecarpum* (Kvaček, Bůžek, and Manchester, 1991) are now known, chiefly through the research of Manchester, to represent two different families. The genus *Craigia* of the Tiliaceae [and] *Dipelta* of the Caprifoliaceae, are now living in southeastern Asia. The present fossils are assigned to an extinct genus, *Diplodipelta*, that is closely allied to *Dipelta*" (p. 55). Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, Fruit; Meyer & Manchester, 1997. *D.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, fruits; Manchester, 2001.

Lonicera sp.- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. *L.* and types- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Sambucus sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

Symphoricarpos salmonensis- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves; Axelrod, 1998a.

Viburnum sp.- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaves; Axelrod, 1998. *V.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole,

2001.

Weigelia- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

CARYOPHYLLACEAE

Stellaria or *Silene*-type- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

CASUARINACEAE

Gymnostoma argentinum, G. archangelskyi, G. patagonicum (branchlets, leaves, infrutescences, fruiting cones)*, G.* male inflorescences (with pollen grains of *Haloragacidites harrisii* type)- Early Eocene (51.91 +/- 0.22 Ma), Tufolitas Laguna del Hunco Fl., northwestern Chubut Province, Argentina; Zamaloa et al., 2006.

Haloragacidites harrisii- lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005.

CELASTRACEAE

Baasia armendarisense- Late Cretaceous (Maastrichtian), McRae Fm., NM, wood; Estrada-Ruiz et al., 2012.

Paxistima deweyensis- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaves; Axelrod, 1998. *P. lemhiensis*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves; Axelrod, 1998a.

CELTIDACEAE- (see Cannabaceae)

CERATOPHYLLACEAE

Ceratophyllum echinatum, C. fossilium- upper Miocene, Esmeralda Fm., NV, fruits, Herendeen et al., 1990; *C. furcatispinum*- Paleocene, Fort Union Fm., MT, fruits,

Herendeen et al., 1990; *C. incertum*- Eocene, Green River Fm., WY, and middle Eocene Claiborne Fm., TN, fruits, Herendeen et al., 1990. *C. lesii*- Upper Cretaceous (late Campanian), Cerro del Pueblo Fm., Coahuila, Mexico, fruit; Estrada-Ruiz et al., 2009. *C.* sp.- Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora, Johnson, 2002; Miocene (15-6 Ma), Iceland, Grimsson & Denk, 2007.

CERCIDIPHYLLACEAE

Cercidiphyllum alalongum- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002. *C. crenatum*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaf; Axelrod, 1998a: ["This species was recorded earlier from Salmon, Idaho, as *Ceanothus*", p. 56]. Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf, fruit; Meyer & Manchester, 1997. Late Miocene- Vasa Park Fl., King Co., WA, leaf (with *C.*-type pollen); Dillhoff et al., 2014. *C. ellipticum*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnston, 2002; Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora, Johnson, 2002. *C. genetrix*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Ludlow Member, Fort Union Fm., ND, SD, megaflora, Johnson, 2002. *C.* sp.- earliest Paleocene, basal Fort Union Fm., ND, seeds, Bercovici et al., 2008; late Paleocene, Almont Fl., Williston Basin, ND, pollen, Zetter et al., 2011; middle Eocene, Republic Fl., WA, pods, Wehr & Manchester, 1996; Miocene (15-6 Ma), Iceland, Grimsson & Denk, 2007. aff. *Cercidiphyllum*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Cercidiphyllum sp.- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011; cf. *Cercdiphyllum*- late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff

et al., 2014.

Joffrea speirsii (*Cercidiphyllum*-like)- late Paleocene, Paskapoo Fm., Joffre Bridge, near Red Deer, Alberta, Canada; pistilate inflorescences, seeds, Stockey & Crane, 1983; Crane & Stockey, 1986; Crane & Stockey, 1985: ["Fossil leaves resembling those of the extant dicotyledon *Cercidiphyllum* Siebold et Zuccarini are widespread in Upper Cretaceous and Tertiary floras throughout North America, Europe, and Asia (Brown 1939; Bell 1949; Iljinskaja 1974; Jahnichen et al. 1980; Tanai 1981)", p. 340]; see also Hoffman & Stockey, 1999' Stockey et al., 2014]. *J.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage, fruits, Dillhoff et al., 2005; middle Eocene, Republic Fl., WA, fruits, seeds, stamens, Wehr & Manchester, 1996.

Nyssidium arcticum- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Sentinel Butte Fm., Almont, ND, follicles, leaves, staminate inflorescences; Crane et al., 1990; Pigg & DeVore, 2010.

"*Populus*" *nebrascensis*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, Megaflora, Johnson, 2002; Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora, Johnson, 2002.

CHENOPODIACEAE/AMARANTHACEAE (see also Amaranthaceae; undifferentiated pollen = chenoam)- latest Eocene (34.1 ma), Florissant Fl., CO, Leopold & Clay-Poole, 2001; late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014.

Chenopodipollis chenopodiaceoides- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012. *C.* sp. 3- Miocene, Tepoztlán Fm., Mexico, pollen; Lendardt

et al., 2013.

CHLORANTHACEAE- fossil record summarized by Herendeen et al., 1993, p. 865.

Chloroanthaceae- Late Cretaceous (Coniacian to Campanian), Antarctic Peninsula, pollen; Poole et al., 2005.

Chloranthistemon crossmanensis (*Chloranthus*-like)- Late Cretaceous (Turonian, ca. 90 Ma), Raritan Fm., NJ, stamens, pollen; Herendeen et al., 1993.

Clavamonocolpites polygonalis- Late Cretaceous (late Maastrichtian), Antarctic Peninsula, pollen; Poole et al., 2005.

Clavatipollenites hughesi- Late Cretaceous (late Maastrichtian), Antarctic Peninsula, pollen; Poole et al., 2005. See also Archangelsky and Taylor (1993), ultrastructure of pollen, early Cretaceous of Patagonia.

Hedyosmum- Antonelli and Sanmartin (2011): "Our results, based on analyses of plastid and nuclear sequences for 40 species, suggst that the ancestor of Chloranthaceae and the *Hedyosmum* stem leneages were widespread in the Holarctic in the Late Cretaceous. High extinction rates, possibly associated with Cenozoic climatic fluctuations. May have been responsible for the low extant diversity of the family. Crown group *Hedyosmum* originated c. 36-43 Ma and colonized South America from the north during the Early-Middle Miocene (c. 20 Ma). This coincided with an increase in diversification rates, probably triggered by the uplift of the Northern Andes from the Mid-Miocene onward" (p. 596). Martínez et al. (2013): "The first appearance of *Hedyosmum*-like pollen was in the Early Cretaceous (~112 Ma). The next unequivocal record of *Hedyosmum*-like pollen (*Clavainaperturites microclavatus*) occurred in the early Miocene" (p. 161). Late Pliocene-Quaternary (ca. 2.7 Ma), High Plain

Bogotá. Colombia, pollen; Hooghiemstra, 1995.

CHRYSOBALANACEAE- Bardon et al. (2013): "… most probably originated in the Palaeotropics about 80 Mya" … dispersed into the Neotropics at least four times beginning 40-60 Mya, with at least one back-dispersal to the Palaeotropics" (p. 19).

Parinari- endocarps and wood, early Miocene, Cucaracha Fl, Canal Zone, Panama, Jud et al., 2016.

CLUSIACEAE

cf. *Calophyllum*- middle Miocene, Pebas Fm., w. Amazon Basin, Iquitos, Peru, wood; Pons & de Franceschi, 2007.

Paleoclusia chevalieri- Late Cretaceous (Turonian), Raritan or Lower Magothy Fm., Sayreville, NJ, flowers, anthers with pollen, young ovules, fruits; Crepet & Nixon, 1998.

Symphonia (*Pachydermites diedrexi*)- "The first pollen fossils of *Symphonia* appear in Africa at ~45 Ma (Jan-du-Chene et al., 1978). The first Mesoamerican fossils of *S. globulifera* appear in the early/middle Miocene (15.5-18.2 Ma; Fournier 1982) and in South America by the mid-Miocene (~15 Ma; Germeraad et al., 1968…and mid-Pliocene (~4 Ma) sediments in Mexico (Graham, 1976; A. Graham, personal communication), in the Plio-Pleistocene of southeast Costa Rica (Graham and Dilcher, 1998…" (Dick et al., 2003, p. 692).

CHOCLOSPERMACEAE (see Bixaceae)

COMBRETACEAE

cf. *Buchenavia*- middle Miocene, Pebas Fm., w. Amazon Basin, Iquitos, Peru, wood; Pons & de Franceschi, 2007.

Dilcherocarpon combretoides- Cretaceous (Albian to Cenomanian), Dakota Fm., KS (Cloud Co.), NB (Decatur), seeds; Manchester & O'Leary, 2010: ["The presence of the Combretaceae in the late Cretaceous has been indicated previously based on well preserved flowers from the Campanian-Maastrichtian of Portugal (Friis et al., 1991) and early Santonian of Japan (Takahashi et al., 1999), but these winged fruits are still older, and provide an additional indication that the syndrome of characters typical of the extant family were established relatively early", p. 63].

Terminalia oregona- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, fruit; Meyer & Manchester, 1997. cf. *Terminalia*- middle Miocene, Pebas Fm., w. Amazon Basin, Iquitos, Peru, wood; Pons & de Franceschi, 2007.

CONNARACEAE

Rourea blatta sp. nov. Jud et Nelson- wood, lower Miocene (19 Ma), Cucaracha Fm, Culebra Cut, Canal Zone, Panama; Jud and Nelson, 2017.

CORNACEAE/CORNALES

Alangium ["Recent molecular data support the conclusion that *Alangium* is close to *Cornus* and should be placed in the Cornaceae" (Wheeleer & Manchester, 2002, p. 36)]. *A. eydei* (fruits), *A. rotundicarpum* (fruits), *A. oregonensis* (wood)- middle Eocene (44 Ma), Clarno Fm., OR; Manchester, 1994, Wheeler & Manchester, 2002. *A.* sp.- late Eocene (36 Ma), lower John Day Fm., OR, endocarps; Manchester & McIntosh, 2007. cf. *Alangium*- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Amersinia obtrullata- Paleocene, WY, MT, ND, Alberta, Canada, China, Kamchatka, northeastern Russia, infructescences, foliage, fruits, seeds, Manchester et al., 1999,

Hoffman & Stockey, 1999; late Paleocene, Almont, Beicegel Fl.s, ND, fruits, seeds, Crane et al., 1990, Manchester et al., 1999, Pigg & DeVore, 2010. *A.* sp.- Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora, Johnson, 2002.

Amersinia/Beringiaphyllum- late Paleocene, Williston Basin, Almont, Beicegel. Golden Valley Fls., Manchester et al., 1999; Pigg & DeVore, 2010.

Beringiaphyllum cupanioides, B. kingiensis, B. pseudoantiquum- Paleocene, "…the presumed leaves of *Amersinia*…" (Manchester et al., 1999). *B. cupanioides*- late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada; Hoffman & Stockey, 1999. *B.* sp.- Almont, Beicegel Fls., ND, leaves, Crane et al., 1990, Manchester et al., 1999, Pigg & DeVore, 2010.

Browniea- late Paleocene, Williston Basin, Ravenscrag Fl., WY; Manchester & Hickey, 2007; Pigg & DeVore, 2010; Zetter et al., 2011.

Caprifoliipites paleocenicus ("…*in situ* in anthers of flowers of the nyssaceous megfossil genus *Browniea* in the Paleocene of Montana (Manchester and Hickey 2007)", (Zetter et al., 2011). *C*. sp.- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011.

Cornophyllum newberryi- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; earliest Paleocene, basal Fort Union Fm., ND, leaves, Bercovici et al., 2008, Johnson, 2002.

Cornus- Manchester et al. (2009) review the fossil record of *Cornus* and based on structurally preserved fossil fruits (Eyde 1988; Manchester 1994; Xiang et al. 2003), leaves of *C. krassilovii* (Russia) and *C. swingii,* and other records, they conclude that "…the extant genus was well established in the Northern Hemisphere early in the

Tertiary" (p. 132). *C. clarnensis*- middle Eocene (44 Ma), Clarno Fm., OR, endocarps; Manchester, 1994. *C. swingii*- Paleocene, Fort Union Fm., WY, MT, ND, leaves; Manchester et al., 2009. *C.* sp./cf. *C.* sp.- Paleocene, Sentinel Butte, Almont, Beicegel Fls., ND, endocarps, Crane et al., 1990, Xiang et al., 2003; Pigg & DeVore, 2010; late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, Dillhoff et al., 2005; middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaf, Axelrod, 1998; Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf, Meyer & Manchester, 1997.

Davidia antiqua- Paleocene, Fort Union Group, ND, MT, WY, leaves, infructescence fruits, Manchester, 2002; Almont Fl., ND, Pigg & DeVore, 2010. *D.* sp.- late Eocene (36 Ma), lower John Day Fm., OR, fruits; Manchester & McIntosh, 2007.

Diplopanax eydei- middle Eocene, Allenby Fm., Princeton Chert, British Columbia, Canada, fruit; Stockey et al., 1998. cf. *Diplopanax*- late Paleocene, Almont Fl., ND, endocarp, Pigg & DeVore, 2010 (pers. comm. from Manchester).

Edencarpa grandis- late Cretaceous, Comox Fm., early Coniacian, Eden Main locality, Vancouver Island, British Colombia, Canada, fruits; Atkibnson et al., 2018.

Eydeia vancouverensis- late Cretaceous, Comox Fm., early Coniacian, Eden Main locality, Vancouver Island, British Colombia, Canada, fruits; Atkinson et al., 2018.

Langtonia bisulcata- Paleocene to earliest Eocene, WY, endocarps, Tiffney & Haggard, 1996; middle Eocene (44 Ma), Clarno Fm., OR, endocarps, locule casts, Manchester, 1994.

Mastixia eydei, M. oregonense, cf. *Mastixia* # 1, cf. *Mastixia* # 2 (Mastixioideae- first appears in the Late Cretaceous of Europe, Knobloch & Mai, 1986)- middle Eocene, Clarno Fm., OR, late Eocene, CA, fruits; Tiffney & Haggard, 1996: ("…widespread in

the early Tertiary of western North America" p. 29, 50). *M.* sp.- middle Eocene (44 Ma), Clarno Fm., OR, endocarp, locule cast; Manchester, 1994; Bighorn Basin, Pigg & DeVore, 2010.

Mastixicarpum occidentale- middle Eocene, Clarno Fm., OR, fruits; Tiffney & Haggard, 1996; endocarps, locule casts; Manchester, 1994. Late Eocene (36 Ma), lower John Day Fm., OR, fruits; Manchester & McIntosh, 2007.

Mastixioidiocarpum oregonense (Scott, 1954, Manchester 1994, Clarno Fl.)- transferred to *Mastixia* (Tiffney & Haggard, 1996).

Nyssa eolignitica- middle Eocene, Claiborne Group, TN, endocarp; Dilcher & Lott, 2005. *N. scottii, N. spatulata, N.* sp.- middle Eocene (44 Ma), Clarno Fm., OR, endocarps; Manchester, 1994. *N.* sp.- late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014.

Nyssapollenites- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011.

Nyssidium arcticum (*Nyssa*)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, leaf; Daly et al., 2011.

Obamacarpa edensis- late Cretaceous,Comox Fm., early Coniacian, Eden Main locality, Vancouver Island, British Colombia, Canada, fruits; Atkinson et al., 2018

Tsukada davidiifolia (probably congeneric with *Davidia,* pers. comm., Steven Manchester to Kathleen Pigg)- middle Eocene, Republic Fl., WA, leaves; Wolfe & Wehr, 1987.

CROSSOSOMATACEAE

Crossosoma sp.- middle Miocene, Mint Canyon Fl. (preliminary study), so. CA; Axelrod, 1940.

CUCURBITACEAE

Lagenaria siceraria (modern)- suggests drift to New World from Africa (rather than Asia) during the Late Pleistocene; Kistler et al., 2014.

CUNONIACEAE

See ?Cunoniaceae, Angiosperm leaf sp. 4, 5, 6, 7; Paleogene, Ligorio Márquez Fm, Argentina; Carpenter et al., 2018.

Caldcluvioxylon collinsensis- middle Eocene, Antarctic Peninsula, wood; Poole et al., 2005.

Cunoniaceae/Elaeocarpaceae- lower middle Eocene, Antarctic Peninsula, pollen (*Tricolporites*); Poole et al., 2005.

Eucryphia cordifolia (Eucryphiaceae)- last interglacial (MIS 5e- called Valdivia in southern Chile), Mancera interglacial sequence, Mancera Island, Chile, leaves; Astorga & Pino, 2011.

Eucryphiaceoxylon eucryphioides- mid-early Paleocene, lower middle Eocene, Antarctic Peninsula, wood, Poole et al., 2005. *E. fildense*- middle Eocene, Antarctic Peninsula, wood, leaf; Poole et al., 2005.

Weinmannioxylon, W. nordenskjoeldii- lower middle Eocene, middle Eocene, Antarctic Peninsula, wood, leaf; Poole et al., 2005. *W. ackamoides, W. nordenskjoeldii*- Late Cretaceous (Coniacian to Campanian), Antarctic Peninsula, wood; Poole et al., 2005.

CYPERACEAE- "Schoeneae originated in Australia in the Paleocene…rapid divergence ca. 50 Ma, in Australia,…traversed the austral oceans with remarkable frequency, a total of 29 distinct dispersal events being reported here. Transoceanic dispersal generally involved habitat stasis" (Vilhoen et al., 2013, p. 2494). See Jiménez-Mejías et al., 2016.

(family)- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. late middle to early late Miocene, Bryn Mawr Fm., MD, pollen; Pazzaaglia et al., 1997.

Cyperacaepollis sp.- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Cyperacites sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, Manchester, 2001; middle Miocene, Mint Canyon Fl., (preliminary study), so. CA, Axelrod, 1940.

CYRILLACEAE

?Cyrillaceae- *Cyrillia* type, late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

DILLENIACEAE

Tuneroxylon newmexicoense (differs in having narrower rays), late Cretaceous, McCrae Fm, south-central New Mexico, wood; Estrada-Ruiz et al., 2018.

DROSERACEAE

Droseridites, Fischeripollis- lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005.

DIOSCOREACEAE (*Dioscorea* fruit listed for the latest Eocene (34.1 Ma) Florissant Fl., CO, Manchester, 2001 now considered uncertain; Manchester, pers. comm., April, 2011).

EBENACEAE

Diospyros sp.- middle Miocene, Mint Canyon Fl. (preliminary study), so. CA; Axelrod,

1940.

ELAEOCARPACEAE (see also Cunoniaceae/Elaeocarpaceae)

Vallea- late Pliocene-Quaternary (ca. 2.7 Ma), High Plain Bogotá, Colombia, pollen; Hooghiemstra, 1995.

ELEAGNACEAE

Eleagnus- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

EPACRIDACEAE/ERICACEAE

Ericipites scabratus- lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005.

ERICALES (Ericaceae or Pyrolaceae; pollen undifferentiated)- latest Eocene (34.1 Ma), Florissant Fl., CO; Leopold & Clay-Poole, 2001.

Raritaniflora tomentosa, R. sphaerica, R. glandulosa (family unplaced, near Cyrillaceae and Ericaceae)- Late Cretaceous (Turonian), Raritan Fm., New Jersey, flowers, pollen, fruits, seeds; Crepet el al., 2013.

ERICACEAE [see also *Azolla,* Bowman, 2014; late Miocene, Vasa Park Fl., King Co., WA, pollen, ericaceous; Dillhoff et al., 2014].

Arbutus sp.- Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO, leaves; Gregory & McIntosh, 1996.

Arctostaphylos cuneata- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaf; Axelrod, 1998. cf. *Arctostaphylos* sp.- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007.

Gaultheria type- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-

Smith & Leopold, 2005.

Ledum idahoensis- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaf; Axelrod, 1998. Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves; Axelrod, 1998a.

cf. *Phyllodoce*- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Tribe Phyllodoceae- Gillespie & Kron (2013): "As a whole, the Phyllodoceae represent a biogeographic pattern consistent with the Arcto-teriary flora, with the majority of extant taxa occurring in the Pacific Northwest of North America, eastern North America, the Caucasus, and eastern Asia" (p.. 761). [see ref. to discussions of the suitability of the geoflora concept in the introduction and in Graham, 1999)]

Rhododendron chaneyi- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves, Axelrod, 1998a. *R. deweyensis*- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaves; Axelrod, 1998. *R.* aff. *ponticum*- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2005. cf. *Rhododendron* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage?, ericaceous pollen; Dillhoff et al., 2005. *R.* sp./cf./type- Miocene (15-6 Ma), Iceland, Grimsson & Denk, 2007; late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005.

Vaccinium deweyensis, V. palaeocorymbosum, V. serrulatum- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaves; Axelrod, 1998. cf. *Vaccinium* sp.- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007.

ERIOCAULACEAE

Paepalanthus- Trovó, et al., 2013): "Biogeographical reconstructions suggest that the

current distribution patterns may be related to vicariance and a few long-distance dispersal events" (p. 225). "The occurrence of both subfamilies in Africa and South America may suggest a Gondwanan origin of Eriocaulaceae, roughly consistent with its crown node estimated at *c.* 105 Mya (Janssen & Bremer, 2004)" (p. 235).

EUCRYPHIACEAE (see Cunoniaceae)

EUCOMMIACEAE

Eucommia- (Call & Dilcher, 1997 review the fossil record of the family for North America): *E. eocenica* (middle Eocene, Mississippi Embayment, MO, TN, MS), *E. montana* (early Eocene to early Oligocene, WA, OR, UT, CO, MT; British Columbia, Canada), *E. constans* (neogene, central Mexico), and *E. jeffersonensis* (latest Eocene or earliest Oligocene, John Day Fm., OR), reproductive and vegetative remains. *E.* sp./type- middle Eocene, Republic Fl., WA, fruit, Wehr & Manchester, 1996; latest Eocene (34.1 Ma), Florissant Fl., CO, fruit, Manchester, 2001; pollen, Leopold & Clay-Poole, 2001; late Miocene, Upper Beluga Fm., south coast Alaska,, pollen, Reinink-Smith & Leopold, 2005.

Eucommia? *leopoldae*- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011.

EUPHORBIACEAE- Dilcher & Manchester (1988, pp. 50-51) discuss the fossil history of the family. Late Eocene (36 Ma), lower John Day Fm., OR, capsule; Manchester & McIntosh, 2007.

Cnidoscolus sp.- Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO, leaves; Gregory & McIntosh, 1996.

Crepetocarpon perkinsii (Tribe Hippomaneae)- middle Eocene, Claiborne Fm.,

TN, fruits; Dilcher & Manchester, 1988.

Croton sp.- latest Eocene (334.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

Hippomaneoidea warmanensis (Subfamily Euphorbioideae, Tribe Hippomaneae)- middle Eocene, Claiborne Fm., western TN, inflorescences, pollen; Crepet & Daghlian, 1982.

Malvacipollis subtilis- lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005.

EUPTELEACEAE

Euptelea dilcherii- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaf; Axelrod, 1998a.

FABACEAE- (for summaries of the fossil record of the family see Crepet & Taylor, 1985, Herendeen & Dilcher, 1990; for the Caribbean region see Graham, 1992).

Leguminosae gen. et sp. indetermined- middle Eocene, Republic Fl., WA, fruits, Wehr & Manchester, 1996; Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaflet, Meyer & Manchester, 1997.

cf. *Abarema* alliance- middle Miocene, Pebas Fm., w. Amazon Basin, Iquitos, Peru, wood; Pons & de Franceschi, 2007.

Acacia- Miocene, Altamira Fm., Dominican amber, flowers, Dilcher et al., 1992; *A.* type- late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005.

cf. *Andira/Hymenolobium*- middle Miocene, Pebas Fm., w. Amazon Basin, Iquitos, Peru, wood; Pons & de Franceschi, 2007.

Arcoa (Caesalpinioideae)- leaves; early Eocene Green River Fm, Wyoming (*A. lindgreni* Herendeen et Herrera, sp. nov.; late Eocene Florissant Fm, Colorado (*A. linearifolia*

(Lesquereux) Herendeen et Herrera, comb. nov.); single living species endemic to Hispaniola; Herendeen and Herrera, 2019.

Barnebyanthus buchananensis (Papilionoideae, Tribe Sophoreae)- early Eocene, Claiborne Fm., Henry Co., TN, flowers with pollen; Crepet & Herendeen, 1992.

Caesalpinites sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaflets; Manchester, 2001.

Calliandra (Mimosoideae)- Miocene, La Ollita Fm., San Juan Province, Argentina, pollen, Caccavari & Barreda (2000): "The first records of Mimosoideae with compound pollen are from the Early Eocene of North America (Crepet and Taylor, 1985), while records for the Middle Eocene are many and the taxa diverse, see for example: Muller (1981), Herendeen (1992), Guinet and Ferguson (1989)… In the Neotropics the fossil pollen record of Mimosoideae is also abundant and varied; Lima and Salard-Cheboldaeff (1981), Lima and Amador (1985); Lima et al. (1985a,b); Caccavari and Anzótegui (1987); Barreda and Caccavari (1992); Graham (1992), Graham and Dilcher (1995)" (Caccavari & Barreda, 2000, p. 197).

Cercis maurerae- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, fruit; Meyer & Manchester, 1997. *C.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, fruits; Manchester, 2001.

Cladrastis oregonensis (leaflet), *C.* sp. (fruit), cf. *C.* (leaflet)- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR; Meyer & Manchester, 1997. *Cladrastis*-like leaves, middle Eocene, Claiborne Group, TN; Dilcher & Lott, 2005.

Crudia grahamiana (Caesalpinioideae, Detarieae)- middle Eocene, Claiborne Fm., TN, fruits, leaflets; Herendeen & Dilcher, 1990. *Crudia*- Eocene, Gatuncillo Fm., Panama, pollen, Graham, 1985; Miocene, La Boca Fm., Panama, pollen, Graham,

1989.

Dichrostachyoxylon herendeenii- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Diplotropis (Papilionoideae, Sophoreae)- middle Eocene, Claiborne Fm., TN, KY, fruits; Herendeen & Dilcher, 1990.

Dodonaeites descaisnei- Oligocene, Armissan, France, early Oligocene Tard Clay, Budapest, Hungary, fruit; Manchester & O'Leary, 2010: ["…almost identical in morphology to *Fissicalyx*" p. 67].

Dusia- "Basian phylogenetic dating techniques suggest that: 1) the uplift of the Andean Mountains created a biogeographical barrier to migration but also contributed to speciation; (2) migration between South America and Central America occurred before the closure of the Panamanian isthmus, indicating that for *Dusia* the Pacific Ocean was less of a barrier than the Andes; and (3) the biogeographic affinities of species from the Chocó biogeographical region are with Central America" (Winterton et al., p.389).

Eocaesalpinia herendeenii- middle Eocene, Lower Claiborne Group, Carroll Country, TX, flower; Dilcher et al., 2014.

Eomimosoidea plumosa (Mimosoideae)- Oligocene, Catahoula Fm., near Huntsville, eastern TX, inflorescence, fruit, pollen; Daghlian et al., 1980 (see also Crepet & Dilcher, 1977).

cf. *Euacacioxylon* sp.- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Gleditsia lottii- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaflets; Axelrod, 1998a.

Hoffmannseggia- Nores et al., 2012: "Simpson & al. (2005), using *Zuccagnia* and

Balsamocarpon as outgroups in their phylogenetic analyses, hypothesized that *Hoffmannseggia* arose in South America and split into a suffrutescent (to shrubby) and an herbaceous clade. During diversification there were at least four independent exchanges between South and North America, potentially mediated by shore birds in the late Cenozoic (late Miocene to Pleistocene). … the spread of *Hoffmannseggia* from South to North America agrees with Simpson & al.'s (2005) proposal. The split of *Stenodrepanum* and *Hoffmannseggia* from a common ancestor resulted in a tolerance of salinity that allowed survival or colonization of the former in this new niche" (p. 797).

Hymenaea allendis, H. mexicana- early Miocene, La Quinta Fm., Simojovel de Allende, Chiapas, Mexico, flowers; Calvillo-Canadell et al., 2010.

Inga eocenica- Eocene, La Carroza Fm., San José de la Popa, Nuevo Leon, Mexico, leaf, leaflets; Calvillo-Canadell et al., 2014.

Leguminocarpon sp.- middle Eocene (44 Ma), Clarno Fm., OR, fruit; Manchester, 1994.

Leguminosites sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaflets; Manchester, 2001.

Lonchocarpus- Da Silva et al. (2012): "Analysis of the molecular data reveals that (1) *Lonchocarpus* s. str. originated about 8.7 +/- 0.05 Ma ago in Central America, in contrast to *Dahlstedtia* and *Muellera* that both arose in South America, 6.3 +/- 0.05 Ma and 8.0 +/- 0.09 Ma ago, respectively; (2) at least three migration events of *Lonchocarpus* have occurred from Central to South America, and one to Africa, the latter best explained by long distance dispersal across the Atlantic Ocean" (p. 93).

Micropodium ovatum- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, fruit; Meyer & Manchester, 1997.

cf. *Mimosoxylon*- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Ormosia-like- middle Eocene, Claiborne Group, TN, leaves; Dilcher & Lott, 2005.

Pickeringia- Wojciechowski (2013): "These results, plus an estimated age of ~31 million years for the genus, further substantiate the hypothesis that *Pickeringia* is geographically isolated in the flora of western North America, an old and phylogenetically distinct lineage of an early diverging group of papilionoid legemes that were much more widely distributed throughout temperate North America and Asia during the Tertiary but whose modern relatives are restricted to southern North America, Central America, and eastern Asia. These findings have implications not only for the evolutionary history of *Pickeringia* but also for the age and development of chaparral vegetation in the California flora" (p. 132). [For related article on the Early Pleistocene history of a hyperdiverse sclerophyll flora in SE Australia, see Sniderman et al., 2013; for caesalipnioids in arid or saline areas of southern South America, see Nores et al., 2012].

Protomimosoidea buchananensis (Mimosoideae, Tribe Mimoseae)- Paleocene-Eocene, Wilcox Fm., Buchanan, TN, flowers with pollen; Crepet & Taylor, 1986.

Robinia californica- middle Miocene, Mint Canyon Fl. (preliminary study), so. CA; Axelrod, 1940.

Swartzia sp.- middle Eocene, Claiborne Group, TN, leaves; Dilcher & Lott, 2005.

FAGACEAE- [re *Castanopsoidea, Paleojulacea, and Trigonobalanoidea* below, "The reproductive structures are the oldest megafossils unequivocally assignable to Fagaceae

and represent the oldest remains of subfamily Fagoideae and the oldest megafossil remains of Castaneoideae" (Crepet & Nixon, 1989, p. 842); see also Crepet, 1989; Nixon & Crepet, 1989; Gandolfo, 1996; an earlier review of the Amentiferae (Fagaceae, Juglandaceae, Ulmaceae) is by Crepet, 1981].

Antiquacupula sulcata- Late Cretaceous (Santonian), Buffalo Creek Member, Gaillard Fm., GA, staminate, bisexual flowers, fruits, cupules, pollen; Sims et al., 1998; Herendeen et al., 1999. [Age revised from Campanian; p. 404].

Berryophyllum tenuifolia, B. sp.- middle Eocene, Claiborne Group, TN, leaves; Dilcher & Lott, 2005.

Cascadiacarpa spinosa- Eocene, Appian Way locality, Vancouver Is., British Columbia, Canada, cupulate fruit; Mindell et al., 2007: ["…the first occurrence of a bipartite gynoecium and the earliest known occurrence of hypogeous fruits in Fagaceae", p. 351; "The fossil record for the family is extensive, going back to the later Cretaceous, where the family is represented by flowers with in situ Normapolles-type triaperturate pollen (Herendeen et al., 1995). During the Paleogene, fossil fruits and flowers appear that can be easily accommodated in the diagnoses of extant genera. These include *Quercus* from Europe (Kvaček and Walther, 1989; Palamarev and Mai, 1998) and North America (Daghlian and Crepet, 1983; Manchester, 1994); *Trigonobalanus* from Europe (Kvaček and Walther, 1989); *Castanea* from Tennessee, USA (Crepet and Daghlian, 1980); and *Fagus* (Manchester and Dilhoff, 2004), *Lithocarpus* and *Castanopsis* (Manchester, 1994) from North America", pp.351-352].

Castanea sp./type- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen, Leopold & Clay-Poole, 2001; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-

Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014.

Castaneoideae sp. 1, 2, 3- middle Eocene, Aamaruutissaa Member, Hareøen Fm., Hareøen Island, western Greenland, pollen; Grímsson et al., 2015

Castaneophyllum sp.- middle Eocene, Klondike Mountain Fm., Republic, WA, leaves; Gandolfo, 1996.

Castanopsis crepetii- middle Eocene (44 Ma), Clarno Fm., OR, fruit; Manchester, 1994. *C.* type- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005. Denk et al. (2019, in press): "Wilf et al. (Research Articles, 7 June, 2019, p. 972) claim that *Castanopsis* originated in Patagonia and spread to its modern distribution in Southeast Asia via Antarctica. However, extensive paleobotanical records of Antarctica and Australia lack evidence of any Fagaceae and molelcular patterns indicate shared biogeographic histories of *Castanopsis, Castanea, Lithocarpus* and *Quercus* subgenus *Cerris* making the southern route unlikely."

Castanopsoidea columbiana- Paleocene/Eocene boundary, near Buchanan, western TN, pistillate inflorescences, fruits, pollen; Crepet & Nixon, 1989. *C. puryearensis*- middle Eocene, Claiborne Fm., Puryear, TN, inflorescences, pollen; Crepet & Daghlian, 1980: "The nature of these fossils is consistent with observations that several other families of the "Amentiferae" evolved rapidly during the Upper Cretaceous-Middle Eocene…" (p. 739).

Catahoulea grahamii- middle Eocene, Claiborne Fm., KY, TN and Oligocene, Catahoula Fm., Huntsville, TX, involucres containing nutlets; DeVore et al. (2014).

Chrysolepis (*Castanopsis*) *lemhiensis*- Oligocene (30.7 Ma), Haynes Creek Fl., ID,

leaves; Axelrod, 1998a.

Cupuliferoidaepollinites liblarensis (*Castanea*)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope, Alaska, pollen; Daly et al., 2011.

Cupuliferoipollenites cingulum subsp. *fusus* (*Castanea*)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, pollen; Daly et al., 2011.

Eotrigonobalanus sp.- middle Eocene, Aamaruutissaa Member, Hareøen Fm., Hareøen Island, western Greeenland, pollen; Grímsson et al., 2015.

Fagaceoxylon ostryopsoides- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Fagopsis undulata- middle Eocene, Klondike Mountain Fm., Republic, WA, leaf, fruit, Gandolfo, 1996; fruits, Wehr & Manchester, 1996. *F.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, inflorescences, fruits, pollen, Manchester, 2001; pollen (in situ), Leopold & Clay-Poole, 2001.

Fagus friedrichii, F. gussonii- Miocene, Selárdalur-Botn Fm. (15 Ma), Dufansdalur-Ketilseyri Fm. (13.5 Ma), Skarðströnd-Mókollsdalur Fm. (9-8 Ma), Iceland, leaves, cupules/nuts; Grímsson & Denk, 2005, 2007. *F. langevinii*- late early to middle Eocene (49-52 Ma), McAbee Fl. (leafy twigs, foliage, cupules, nuts, *Fagus* pollen), British Columbia, Canada, and Republic Fl., WA, fruits, foliage, pollen; Manchester & Dillhoff, 2004: ["…provide an earlier record for the genus *Fagus* than previously accepted for this member of the Fagaceae. Previously, the oldest *Fagus* occurrences confirmed by fruits were early Oligocene (ca. 32 Ma). The recognition of Middle Eocene (ca. 50 Ma) representatives helps reduce the disparity between molecular evidence favoring *Fagus* as a primitive genus within Fagaceae, and fossil evidence,

which had indicated older occurrences of *Castanea* and *Quercus* than *Fagus*" (p. 1509)]. *F. pacifica*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, fruit; Meyer & Manchester, 1997. *F. schofieldii*- middle Eocene, Oyster Bay Fm., Appian Way locality, Vancouver Is., British Columbia, Canada, fruits; Mindell et al., 2009: ["…represent the first permineralized Fagaceae of subfamily Fagoideae in the fossil record" and "provides the earliest evidence of winglessness in Fagoideae and supports the possibility of a North American origin for the genus" (p. 551). *Fagus washoensis*- late Miocene, Vasa Park Fl., King Co., WA, leaf, Dillhoff et al., 2014; *F.* sp.- late Eocene (36 Ma), lower John Day Fm., OR, nut, Manchester & McIntosh, 2007; latest Eocene (34.1 Ma), Florissant Fl., CO, pollen, Leopold & Clay-Poole, 2001; middle Eocene, Klondike Mountain Fm., Republic, WA, leaves; Gandolfo, 1996; late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997. *F.* and types- late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014. *Fagus* sp.- middle Eocene, Aamaruutissaa Member, Hareøen Fm., Hareøen Island, western Greenland, pollen; Grímsson et al., 2015.

Faguspollenites sp. (*Fagus*)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Knightiophyllum wilcoxianum- middle Eocene, Claiborne Group, TN, leaves; Dilcher & Lott, 2005.

Lithocarpus weidei- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves, fruits; Axelrod, 1998a. *L.* sp.- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaves; Axelrod, 1998.

Paleojulacea laxa- Paleocene/Eocene boundary, near Buchanan, western TN, catkins, pollen; Crepet & Nixon, 1989.

Protofagacea allonensis- Late Cretaceous (Santonian), Buffalo Creek Member, Gaillard Fm., GA, flowers, fruits, cupules, pollen; Herendeen et al., 1995, 1999. [Age revised from Campanian].

Quercinium centenoae- Late Cretaceous (late Campanian-early Maastrichtian), Olmos Fm., Coahuila, Mexico, wood; Estrada-Ruiz et al., 2007. *Q. crystallifera*- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Quercoidites (sp. 1, 2, 3 *Quercus*)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Quercus berryi, Q. consimilis, Q. sp.- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaves, fruit; Meyer & Manchester, 1997. *Q. bilobata, Q. castormontis, Q. haynesii, Q. lemhiensis, Q. moyei, Q. predayana, Q. snookensis*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves; Axelrod, 1998a. *Q. catahoulaensis* (leaves), *Q. oligocenensis* (staminate catkins, pollen), *Q. huntsvillensis* (fruits)- Oligocene, Catahoula Fm., near Huntsville, TX; Daghlian & Crepet, 1983. *Q. pollardiana, Q. prelobata, Q. simulata*- late Miocene (Clarendonian, 12 Ma), Ironside Fm., OR, leaves; Retallack, 2004. *Q. deweyensis*- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaves; Axelrod, 1998. *Q. paleocarpa*- middle Eocene (44 Ma), Clarno Fm., OR, acorn; Manchester, 1994. *Q. convexa, Q. dispersa, Q. lakevillensis*- middle Miocene, Mint Canyon Fl., (preliminary study), so. CA; Axelrod, 1940. *Q.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, pollen, Dillhoff et al., 2005; latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, fruits, Manchester, 2001; pollen, Leopold

& Clay-Poole, 2001; late Eocene (36 Ma), lower John Day Fm., OR, acorn, Manchester & McIntosh, 2007; ?*Q*. sp.- middle Eocene, Klondike Mountain Fm., Republic, WA, leaf, Gandolfo, 1996; late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997. *Q*. and types- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005. Late Miocene, Vasa Park Fl., King Co., Wa, pollen, Dillhoff et al., 2014. *Quercus* sp. 1-7- middle Eocene, Aamaruutissaa Member, Hareøen Fm., Hareøen Island, western Greenalnd, pollen; Grímsson et al., 2015.

Sabinoxylon pasac (Fagaceae?)- Late Cretaceous (late Campanian-early Maastrichtian), Olmos Fm., Coahuila, Mexico, wood; Estrada-Ruiz et al., 2007.

Tricolporopollenites sp. 1 (*Castanea*)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Trigonobalanoidea americana- Paleocene/Eocene boundary, near Buchanan, western TN, psilate infructescences, dispersed fruits; Crepet & Nixon, 1989.

FLACOURTIACEAE

Casearia- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

Saxifragispermum tetragonalis- middle Eocene (44 Ma), Clarno Fm., OR, fruits; Manchester, 1994.

GENTIANACEAE- Lower Eocene, Wilcox Fm., northeastern TX; flowers with *Pistillipollenites macgregorii* pollen; Crepet & Daghlian, 1981. Merckx et al. (p. 719): "… the current distribution patterns of Gentianaceae lineages in South America strongly suggest that the Guiana Highlands have played a prominent role in the early diversification of Gentianaceae" (p. 719); "… molecular and morphological analyses of

Helieae suggest that at least a few of these Guiana Highalnd genera are early diverging lineages of the tribe (Struwe et al., 2009a [2009 in ref.]). Thus we speculate that Gentianaceae arose in the Guiand Shield during the Cretaceous, similar to what is inferred for Bromeliaceae (Givnish et al., 2011) and Rapateaceae (Givnish et al., 2004; Jansen and Bremer, 2004)" p. 719.

Voyria- Merckx et al. (2013): "… originated in the neotropics during the Early Eocene but only reached its current transoceanic distribution around the end of the Oligocene. The neotropics were an important area for the early diversification events in Gentianaceae, most of which occurred during the Eocene" (p. 712). "… migration of tropical taxa thorugh Laurasia during the Early Eocene has played an important role in shaping the current global distribution of Gentianaceae" (p. 712). "The estimates date the crown node of Gentianaceae between 47.3 and 69.1 Ma (T1) or 54 and 78.6 Ma (T2). The divergence of *Voyria primuolides* is estimated to have occurred between 12.2 and 26.5 Ma (T1) or 12.4 and 27.7 Ma (T2)" (p. 715). "Under all models (M0, M1, M2) and topologies (T1, T2) the neotropics are inferred to be part of the ancestral area of the common ancestor of Gentianaceae, either as the sole ancestral area or together with the paleotropics" (p. 715). See also Estimation of divergence times (p. 714, 715); Ancestral area reconstructions (p. 714, 715; Table 3); Trans-Atlantic distribution of *Voyria* (p. 715-717); Early diversification history of Gentianaceae (p. 717-719).

GESNERIACEAE- Perret et al. (2013): "Based on molecular dating and biogeographical reconstruction analayses, we suggest that ancestors of Gesneriaceae originated in South America during the Late Cretaceous. Distribution of Gesneriaceae in the Palaeotropics

and Australasia was inferred as resulting from two independent long-distance dispersals during the Eocene and Oligocene, respectively" (p. 61). [see also Table 1, p. 65].

GROSSULARIACEAE

Ribes sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage, Dillhoff et al., 2005; middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaf, Axelrod, 1998; latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, Manchester, 2001; Oligocene (32.9- Ma), Pitch Pinnacle Fl., CO, leaves, Gregory & McIntosh, 1996*;* Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf, Meyer & Manchester, 1997.

GUNNERACEAE

Clavamonocolpites polygonalis- mid-early Paleocene, Antarctic Peninsula, pollen; Poole et al., 2005.

Gunnera (*Tricolpites reticulatus*)- Late Cretaceous (late Campanian-Maastrichtian), Vega Is., Antarctic Peninsula, pollen; Wanntorp et al., 2004: ["…the genus has a well-documented and relatively unbroken fossil record from the Early Cretaceous to present"; "Almost as old as these fossils...attributable to *Gunnera* (Jarzen, 1980; Jarzen and Dettmann, 1989) are the Turonian (about 90 Ma) specimens from Peru (Brenner, 1968)" (p. 169)].

Tricolpites confessus- Late Cretaceous (late Maastrichtian, Antarctic Peninsula, pollen; Poole et al., 2005. *T. reticulatus*- lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005. *T.* sp.- mid-early Paleocene, Antarctic Peninsula, pollen; Poole et al., 2005. *T. waiparaensis*- Late Cretaceous (late Maastrichtian), Antarctic Peninsula, pollen; Poole et al., 2005. [*Gunnera*].

HALORAGIDACEAE

Haloragacidites- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Myriophyllum- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

HAMAMELIDACEAE- Benedict et al. (2008, pp. 687-688) review the fossil record of the family; for 'higher' Hamamelidae see Crane & Blackmore, 1989; Juglandaceae-Rhiopteleaceae-Myricaceae-Betulaceae see Sims et al., 1999; Normapolles pollen see Batten, 1989. Paleocene, Sentinel Butte Fm., Almont, ND, staminate inflorescences, infructescences; Crane et al., 1990. gen. et sp. indetermined (infructescence)- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR; Meyer & Manchester, 1997.

Allonia decandra- Late Cretaceous (late Santonian), Buffalo Creek Member, Gaillard Fm., Allon Fl., GA, flower, associated seeds; Herendeen et al., 1999.

Corylopsis reedae- Lower Eocene (49-50 Ma), Republic Fl., WA, leaf; Radtke et al., 2005: ["Today this genus occurs only in Asia, but the fossil record, primarily of seeds, indicates it was widely distributed in North America and Europe during the Tertiary" (p. 347)].

Fothergilla malloryi- Lower Eocene (49-50 Ma), Republic Fl., WA, leaf; Radtke et al., 2005: ["…oldest record for the genus, which is also known in the Oligocene of North America and several Neogene Asian localities" (p. 347)]. *F. praeovata*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997.

Fortunearites endressii- middle Eocene (44 Ma), Clarno Fm., OR, infructescence, fruits; Manchester, 1994.

Hamamelidoxylon uniseriatum- middle Eocene (44 Ma), Clarno Fm., OR, wood;

Wheeler & Manchester, 2002.

Hamawilsonia boglei- Late Paleocene (Tiffanian 3), Sentinel Butte Fm., Almont Fl., ND, infrutescence, fruits, seeds, associated pollen catkins with in situ tricolpate pollen; Benedict et al., 2008: ["…an extinct Late Paleocene genus with a combination of characters not seen in any extant hamamelid genus" (p. 687)]; Crane et al., 1990, Pigg & DeVore, 2010.

Langeria magnifica- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage, Dillhoff et al., 2005; middle Eocene Republic Fl., Wa, leaves [extinct genus established by Wolfe & Wehr, 1987 for large leaves with hooklike teeth. Steven Manchester considers whether these might be Platanaceae (pers. comm., to Kathleen Pigg); Pigg, pers. comm., 2011].

Parrotia brevipetiolata- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997.

Retitrescolpites anguloluminosus (aff. originally cited as with *Salix* fide Norton & Hall, 1969; now with Hamamelidaceae, e.g., *Corylopsis*, Zetter et al., 2011)- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011.

Retitrescolpites catenatus ("The pollen is known *in situ* from catkins associated with *Hamawilsonia* infructescences (Benedict et al., 2008). *Hamawilsonia* is an extinct genus known from anatomically preserved fruits, infructescences, and seeds that combines features of *Sinowilsonia, Hamamelis* and several other extant genera of Hamamelidaceae." Zetter et al., 2011, pp. 196-197)- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011.

Subfamily Altingioideae- Late Cretaceous (late Santonian), Buffalo Creek Member,

Gaillard Fm., Allon Fl., GA, inflorescences and pistillate flowers; Herendeen et al., 1999.

HAMAMELIDACEOUS/PLATANOID AFFINITIES- Late Cretaceous, Raritan Fm. (Turonian, ca. 88.5-90.4 Ma), NJ, staminate, pistillate inflorescences, detached stamens, pollen; Crepet et al., 1992. Fragments of platanoid foliage- Lower Cretaceous (upper Albian), Potomac Group, VA; Upchurch et al., 1994. Subclass Rosidae and Hamamelididae- *Sapindopsis magnifolia/variabilis, S. minutifolia*, Lower Cretaceous (upper Albian), Potomac Group, VA, leaves; Upchurch et al., 1994.

HELIOTROPIACEAE (see also Boraginaceae)- "Timing of the diversification in the Andean lineages of *Heliotropium* sects. *Heliothamnus, Cochranea, Heliotropium, Hypsogenia, Plagiomeris, Platygyne* clearly correspond to a rapid, late Miocene uplift of the Andes and a Pliocene development of arid environments in South America" (Luebert et al., 2011).

HERNANDIACEAE

Illigera eocenica- middle Eocene, Clarno Fm., Jefferson Co., OR, Green River Fm., CO, UT, WY, Wagon Bed Fm., WY, fruits; Manchester & O'Leary, 2010. [As *Ptelea cassioides* in MacGinitie, 1969].

HIPPOCASTANACEAE (SAPINDACEAE)

Aesculus hickeyi- Paleocene, Fort Union Fm., ND, WY, leaves, fruits; Manchester, 2001: ["…traditionally placed…in the Hippocastanaceae…some phylogenetic evaluations place [it] as a clade within the Sapindaceae…" (p. 985)]. *Aesculus* sp.- Williston Basin, Almont Fl., ND, leaf, Manchester 2001, Pigg & DeVore, 2010; late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage, Dillhoff et al., 2005;

Miocene (15-6 Ma), Iceland, Grimsson & Denk, 2007.

HUMIRIACEAE- Herrera et al., 2010: "A review of prior published reports of fossil fruits attributed to Humiriaceae led to the rejection and/or reattribution of some records but supports recognition of *Vantanea, Humiria, Humiriastrum, and Sacoglottis*. The available characters do not support recognition of multiple fossil species of *Sacoglottis.* We recognize the occurrence of *Sacoglottis tertiaria* Berry emend. Herrera from Peru, Ecuador, Colombia, and a newly collected Miocene site from Panama. The Cenozoic fossil record of Humiriaceae in South and Central America, together with discreditation of former reports from Europe, strongly supports a Neotropical origin for this family" (p. 392). "In total, 15 reports of fossil endocarps and pollen are upheld as valid for Humiriaceae: *Vantanea* (Eocene and Miocene), *Sacoglottis* (Early Miocene and Late Pliocene), *Humiria* (Miocene and Pliocene), *Humiriastrrum* (Miocene and Early Pliocene)" (p. 406).

cf. *Humariastrum*- middle Miocene, Pebas Fm., w. Amazon Basin, Iquitos, Peru, wood; Pons & de Franceschi, 2007.

Lacunofructus cuatrecasana- late Eocene, Tonosi Fl., Pacific coast central Panama, seed; Herrera et al., 2012. Genus *Lacunofructus* Herrera, Manchester et Jaramillo, here emended, *Lacunofructus cuatrecasana Herrera, Manchester et Jaramillo*, endocarp, Oligocene, west Azuero Peninsula, Panama, Pérez-Consuegra et al. 2018.

cf. *Sacoglottis* sp..earlly Miocene, west Azuero Peninsula, Tonosi Fm?, Panama, Péres-Consuegra et al., 2018.

HYDRANGEACEAE

Hydrangea bendirei- late Miocene, Vasa Park Fl., King Co., WA, leaf, Dillhoff et al.,

2014; *H. knowltonii*- middle Eocene (44 Ma), Clarno Fm., OR, infructescence, seeds; Manchester, 1994. *H.* sp.- latest Eocene (34.1 Ma), Florisscant Fl., CO, calyces, Manchester, 2001, Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, infructescence, calyx, Meyer & Manchester, 1997.

Philadelphus-like leaves- latest Eocene (34.1 Ma), Florissant Fl., CO; Manchester, 2001.

ICACINACEAE- Kvaček & Bůžek (1995) and Rankin et al. (2008, p. 305) review the fossil record of the family, and the biogeography is summarized by Manchester (1999).

Comicilabium atkinsii- middle Eocene (44 Ma), Clarno Fm., OR, endocarps, locule casts; Manchester, 1994.

Croomiocarpon mississippiensis- early-middle Eocene (Claiborne Group), Tallahatta Fm., MS, fruit; Stull et al., 2011.

Icacinicarya collinsonae- late Paleocene, Almont Fl., ND, endocarp, Pigg et al., 2008; Pigg & DeVore, 2010. *P. dictyota*- late Paleocene, Beicegel Fl., ND, endocarp; Pigg et al., 2008.

Iodes multireticulata, I. chandlerae- middle Eocene (44 Ma), Clarno Fm., OR, endocarps, locule casts, seeds; Manchester, 1994. *I.* sp.- middle Eocene, Republic Fl., WA, fruit; Wehr & Manchester, 1996.

Iodicarpa ampla, I. lenticularis- middle Eocene (44 Ma), Clarno Fm., OR, fruits; Manchester, 1994.

Natsiatum wilcoxiana- Middle Eocene (Claiborne Group), Grenada and Cockfield Fms., TN, fruits; Stull et al., 2011.

Palaeophytocrene handcockii, P. pseudopersica- middle Eocene (44 Ma), Clarno Fm., OR, endocarps; Manchester, 1994. *P. hammenii*- middle-late Paleocene, Bogatá Fm.,

Cundinamarace, Colombia; Stull et al., 2012. *P. piggae*- late Paleocene, Sentinel Butte Fm., Almont, ND, endocarps, Stull et al., 2012. *P. vancouverensis*- Eocene, Oyster Bay Fm., Appian Way locality, Vancouver Is., British Colombia, Canada, endocarp; Rankin et al., 2008. *P.* sp.- Paleocene, Sentinel Butte Fm., Almont, ND, fruits, Crane et al., 1990, Pigg & DeVore, 2010. Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, endocarp, Meyer & Manchester, 1997.

Phytocrene densipunctata- middle Eocene (Claiborne Group), Cockfield Fm., TN, fruits; Stull et al., 2011.

Platea- Paleocene, Oak Hill Member, Naheola Fm., Alabama, pollen (*Favitricolporites baculoferus*); Lobreau-Callen & Srivastava, 1974.

Pyrenacantha austroamericana- late early Oligocene, Belén Fl., Peru, endocarps; Stull et al, 2012. *P. occidentalis*- middle Eocene (44 Ma), Clarno Fm., OR, endocarps; Manchester, 1994.

ILLICIACEAE

Illicioxylon- Late Cretaceous (Coniacian to Campanian), Late Cretaceous (late Maastrichtian), mid-early Paleocene, Antarctic Peninsula, wood, Poole et al., 2005.

JUGLANDACEAE- see Manos et al., 2007; an earlier review of the Amentiferae (Fagaceae, Juglandaceae, Ulmaceae) is by Crepet, 1981. See also Sims et al. (1999), fossil flowers with Normapolles pollen possibly of the 'higher' hamamelids- Juglandaceae, Rhiopteleaceae, Myricaceae, Betulaceae.

Alatomucula ignis (Juglandaceae, subfamily Engelhardioideae)- early Eocene, Laguna del Hunco Fl., Chubut Province, Patagonia, Argentina, pedicellate fruit; Hermsen and Gandolfo, 2016.

Alfaroa (*Oreomunnea/Engelhardia/Alfaroa* pollen (*Momipites*) undifferentiated- latest Eocene (34.1 Ma), Florissant Fl., CO, Leopold & Clay-Poole, 2001; see also Hansen et al., 2001.

Beardia vancouverensis- Eocene, Appian Way locality, Vancouver Is., British Columbia, Canada, fruits; Elliott et al., 2006.

Carya bendirei- late Miocene (Clarendonian, 12 Ma), Ironside Fm., OR, leaf; Retallack, 2004. *C.* sp./type- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, Dillhoff et al., 2005; latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, leaflets, staminate inflorescences, fruits, Manchester, 2001, pollen, Leopold & Clay-Poole, 2001; late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997. *C.* sp. 1 (leaflet), *C.* sp. A (fruit)- Oligocene (33.6-32.2 Ma), John Day Fm., OR, nuts, Manchester & McIntosh, 2007; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014. *Carya* type- late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005. *Carya/Juglans*- middle Eocene, Republic Fl., WA, fruit; Wehr & Manchester, 1996.

Caryapollenites imparalis- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011. *C.* sp.- Miocene, Tepoztlán Fm., Mexico, pollen, Lenhardt et al., 2013.

Casholdia- (England and France; see *Polyptera*).

Clarnoxylon blanchardii- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Cruciptera simsonii- middle Eocene (44 Ma), Clarno Fm., OR, samara; Manchester, 1994. *C.* sp.- middle Eocene, Republic Fl., WA, fruit, Wehr & Manchester, 1996;

Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, fruit, Meyer & Manchester, 1997.

Cyclocarya- (see also *Polyptera*)- *C. brownii*- Paleocene, Sentinel Butte Fm., Almont, Beicegel Fls., ND, fruits, leaves, Crane et al., 1990, Manchester & Dilcher, 1982, Pigg & DeVore, 2010, Taylor 2007. *C.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001. cf. *Cyclocarya*- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Engelhardioxylon nutbedensis- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002. *Engelhardia/Alfaroa[/Oreomunnea*] pollen- latest Eocene (34.1 Ma), Florissant Fl., CO; Leopold & Clay-Poole, 2001. *E.*-type, late middle to early late Miocene, Bryn Mawr Fm., MD, pollen; Pazzaglia et al., 1997.

Eoengelhardia puryearensis- middle Eocene, Claiborne Fm., TN, catkins, pollen; Crepet et al., 1980.

Eokachyra aeolius- middle Eocene, Claiborne Fm., Weakly County, TN, catkins, pollen; Crepet et al., 1975: ["Three different juglandaceous pollen types had already differentiated by the Upper Cretaceous (Nichols, 1973), and by the Middle Eocene the Juglandaceae are represented by a variety of fruit types (Berry, 1916; Scott, 1954; MacGinitie, 1969)", p. 813].

Juglandicarya- (see *Polyptera*)

Juglandiphyllites cryptatus- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaflet; Meyer & Manchester, 1997.

Juglans clarnensis- middle Eocene (44 Ma), OR, fruit; Manchester, 1994. *J. wheelerensis*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR,

leaflet; Meyer & Manchester, 1997. *J.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, Dillhoff et al., 2005; latest Eocene (34.1 Ma), Florissant Fl., CO, pollen, Leopold & Clay-Poole, 2001; late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014. *J. bergomensis*- Miocene, North America, nut, Smith and Manchester, 2018.

Momipites annelus ("Grains of this type occur *in situ* within catkins that consistently co-occur with the extinct genus *Polyptera* (Manchester & Dilcher, 1982, 1997; Manchester, 1989", Zetter et al., 2011). *M. triorbicularis*- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011. *M.* sp.- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, pollen; Daly et al., 2011. Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012. *M.* sp. (*Engelhardtia*)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Oreopanax grahamii- early Miocene, Lower Cucaracha Fm., Gaillard Cut, Canal Zone, Panama, fruits, Herrera et al., 2014.

Palaeocarya cf. *olsonii*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, fruit; Meyer & Manchester, 1997. cf. *Palaeocarya clarnensis*- middle Eocene (44 Ma), Clarno Fm., OR, nutlets, locule casts; Manchester, 1994 (probably *Engelhardia*, Manchester, pers. comm., April, 2011).

Palaeoplatycarya? hickeyi- middle Eocene (44 Ma), Clarno Fm., OR, infructescences, locule casts; Manchester, 1994.

Platycarya sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-

Poole, 2001. cf. *Platycarya*- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Polyptera manningii (Hicorieae, Juglandeae)- Paleocene, Fort Union Fm., 56-64 Ma, WY, MT, infructescences, fruits, staminate catkins, leaves, pollen; Manchester & Dilcher, 1997: ["Occurrences in the Torrejonian and Tiffanian stages of the Paleocene place *Polyptera* as the oldest unequivocal record of Juglandaceae" p. 649; "Four genera are known based upon fruits from the Paleocene: *Cyclocarya* from Wyoming, Montana, and North Dakota (Manchester and Dilcher, 1982; Manchester, 1987, 1989), *Casholdia* from England and France (Crane and Manchster, 1982; Manchester, 1989), *Juglandicarya* (Brown, 1962; Manchester, 1987, 1989), and *Polyptera* (Manchester and Dilcher, 1982; Manchester, 1987, 1989) from Wyoming and Montana", p. 649]; Pigg & DeVore, 2010.

Pterocarya idahoensis- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaflet; Axelrod, 1998. *P. occidentalis, P.* sp.- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fm., OR, leaflet, fruit; Meyer & Manchester, 1997. *P.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, Dillhoff et al., 2005; latest Eocene (34.1 Ma), Florissant Fl., CO, pollen, Leopold & Clay-Poole, 2001; Miocene (15-6 Ma), Iceland, Grimsson & Denk, 2007; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014.

LAMIACEAE/LAMIALES

Cruxifructus eocenicus (Verbenaceae/Lamiaceae)- late Eocene, Tonosi Fl., Pacific coast central Panama, fruit; Herrera et al., 2012.

Lepechinia- Drew & Sytsma (2011): "This preliminary sampling of *Lepechinia* (and other Salviinae) thus suggests the hypotheses that (1) the subtribe Salviinae originated in Eurasia, (2) *Lepechinia* s.l. first diversified in Mexico (or more broadly in Central America), (3) at least two movements out of Mexico and susbsequent radiations in South America occurred, and (4) at least one radiation from Mexico to Mediterranean California occurred" (p. 1046). Drew & Sytsma (2013): "Divergence time estimation using BEAST shows *Lepechinia* had a mid/late Miocene origin, perhaps as a response to global cooling patterns. Cladogenesis in most South Amrican *Lepechinia* is shown to have occurred within the past 5 Myr, presumably as a response to climatic and orogenic events" (p. 171).

Pogogyne- Silveira & Simpson (2013): … "stem node is estimated…to have arisen an average of 5.1-7.7 million years ago, although with considerably wide confidence intervals. This date corresponds well with the *Pogogyne* stem node age of approximately 6 million years ago from the analyses of Drew and Sytsma (2012)…" (p. 793). … "for that of the crown node is 0.9-1.9 million years ago…" (p. 782). "This compares with an estimated age of 0.6-4 million years before present for many vernal pool soils…dates are quite rough estimates…" (p. 793).

LAURACEAE

See Chandler et al., 2018, Lauraceae sp. 1-3, Paleogene, Ligorio Márquez Fm, Argentina; leaf/cuticle remains.

See Chanderbali et al., 2001; Rohwer, 1993; Little et al., 2009: ["The diverse fossil record of Lauraceae begins in the Cretaceous and includes flowers, fruits, leaves, and wood (Drinnan et al., 1990; Herendeen, 1991; Kvaček, 1992; Herendeen et

al., 1994; Crane et al., 1994), Eklund and Kvaček, 1998; Mickle, 1996; Frumin et al., 2004). Fruits and cupulate structures commonly occur throughout the fossil record (Chandler, 1964; Mai, 1971, 1999, 2001; Manchester, 1994, Pingen et al., 1994; Eklund, 2000; Frumin et al., 2004), but few are known anatomically, with some exceptions (Drinnan et al., 1990; Eklund and Kvaček, 1998; Frumin et al., 2004)" p. 637].

See Nishida and van der Werff (2011): "Cuticular characters…are often used in the taxonomy and classification of fossil or extant Lauraceae. However, there is no concensus on their usefulness, especially as to which characters take priority and at which taxonomic level. Because the number of character states is limited, cuticle features by themselves cannot be used to define genera or clades or will not alow the identification of specimens" (p. 348). The main obstacle is that genera like *Ocotea* and *Nectandra* (and probably the large Asian genera *Litsea* and *Lindera*) are not monophyletic. However, if leaf fossils thought to be Lauraceous, and with preserved cuticles that can be studied microscopically by specialists familiar with both cuticle morphology and the systematics of the Laruaceae, it may be possible in some instances to refer the specimens to an extant genus. It would be interesting to assemble such specimens for examination (van der Werff, pers. comm., 2011).

Araliaphyllum polevoi- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

"*Artocarpus*" *lessigiana*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Bisonia niemii- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora;

Johnson, 2002.

Cinnamomophyllum bendirei, C. knowltonii- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaves; Meyer & Manchester, 1997.

Cinnamomoxylon oleiferum- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002. *C.* sp.- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

Cissites insignis, C. lobata, C. puilosokensis- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Cryptocaryoxylon hancockii, C. meeksii, C. radiporosum- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

"*Ficus*" *planicostata*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Goeppertia- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

Laurinoxylon stichkai- late early Eocene (ca. 49 Ma), Bridger Fm., Big Sandy Reservoir, SW Wyoming, wood; Bounchai & Manchester, 2101. *L. rennerae* (variously Cinnamomeae, Laureae, Lauroideae), late Cretaceous (upper Campanian, 76.5->72.5 Ma), McRae Fm, south-central New Mexico; woods; Estrada-Ruiz et al., 2018.

Laurocalyx wheelerae- middle Eocene (44 Ma), Clarno Fm., OR, fruit; Manchester, 1994.

Laurocarpum hancockii, L. nutbedensis, L. raisinoides- middle Eocene (44 Ma), Clarno Fm., OR, fruits; Manchester, 1994.

Laurophyllum sp. 1 ("*Laurus*")- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007.

Lindera clarnensis- middle Eocene (44 Ma), Clarno Fm., OR, endocarps, seeds,

cotyledons; Manchester, 1994.

Litseaphyllum presanguinea- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997.

Marmarthia pearsonii, M. trivialis- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Mauldinia sp.- Late Cretaceous (late Santonian), Buffalo Creek Member, Gaillard Fm., Allon Fl., GA, inflorescence units, flowers; Herendeen et al., 1999.

Mezilaurinoxylon eiporosum- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Nectandra- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

Notophoebe- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

Ocotea obtusifolia- Eocene, TN, leaves; Dilcher, 1963. *O*. sp.- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves, Gayó et al., 2005; middle Eocene, Claiborne Group, TN, leaves, Dilcher & Lott, 2005.

Paraperseoxylon scalariforme- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Paraphyllanthoxylon marylandense- mid-Cretaceous (Cenomanian), Potomac Group, wood; Herendeen, 1991: ["…established by Bailey (1924) for angiosperm wood from the Upper Cretaceous of Arizona…Subsequently, numerous *Paraphyllanthoxylon* species have been described from Cretaceous and Tertiary sediments in North America, Europe, South Africa, India, and Japan (Spackman, 1948; Mädel, 1962; Cahoon, 1972; Thayn et al., 1983; Thayn and Tidwell, 1984; Prakash et al., 1986; Wheeler et al., 1987; Wheeler, 1991", p. 277].

Persea pseudocarolinensis- late Miocene, Vasa Park Fl., King Co., WA, leaf, Dillhoff et al., 2014; *P.* sp- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

Perseanthus crossmanensis- Late Cretaceous (Turonian), Raritan Fm., NJ, flowers, pollen; Herendeen et al., 1994.

Phoebe- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

Sassafras ashleyi- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves; Axelrod, 1998a. *S. ferrettianum*- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. *S. hesperia*- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage; Dillhoff et al., 2005.

Sassafrasoxylon- Late Cretaceous (Coniacian to Campanian), Late Cretaceous (late Maastrichtian), Antarctic Peninsula, wood; Poole et al., 2005.

Ulminium magnioleiferum- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeleer & Manchester, 2002.

LAURALES

Dicotylophyllum ovato-decurrens- Lower Cretaceous (upper Albian), Potomac Group, VA, leaves; Upchurch et al., 1994.

Landonia cf. *L. calophylla*- Lower Cretaceous (upper Albian), Potomac Group, VA, leaf fragment; Upchurch et al., 1994.

aff. *Pabiania* sp. 1- Lower Cretaceous (upper Albian), Potomac Group, VA, leaves; Upchurch et al., 1994.

LECYTHIDACEAE

cf. *Cariniana*- middle Miocene, Pebas Fm., w. Amazon Basin, Iquitos, Peru, wood; Pons

& de Franceschi, 2007.

cf. *Echweilera*- middle Miocene, Pebas Fm., w. Amazon Basin, Iquitos, Peru, wood; Pons & de Francheschi, 2007.

LEMNACEAE

Limnobiophyllum scutatum- Paleocene, Paskapoo Fm., near Red Deer, Alberta Canada, leaves, stolons, roots, staminate flowers, pollen; Stockey, Hoffman, & Rothwell (1997): ["Results of the [cladistic] analysis indicate that the Lemnaceae plus *Pistia* form a monophyletic group within the Araceae" (p. 355)]; Pigg & DeVore, 2010.

LILIACEAE [pollen attributed to the Liliaceae, Vasa Park Fl., King Co. WA, late Miocene; Dillhoff et al., 2014].

Liliacidites- Late Cretaceous (late Maastrichtian), lower middle Eocene, Antarctic Peninsula, pollen, Poole et al., 2005. *L. kaitangataensis*, *L. variegates, L.* sp.- mid-early Paleocene, Antarctic Peninsula, pollen; Poole et al., 2005.

Monocolpopiollenites sp.- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

LIMNOCHARITACEAE

Cardstonia tolmanii- Upper Cretaceous (Campanian-Maastrichtian), St. Mary Fm., Alberta, Canada, leaves; Riley & Stockey, 2004.

LINACEAE

Hesperolinon- '…endemic to western United States, most diversification taking place in the past 1-2 Ma, based on five plastid and two ribosomal nuclear DNA gene regions,' Schneider et al., 2016.

LOGANIACEAE

Rhoipites mimusculus- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Strychnos electri- mid-Tertiary Dominican amber (age range 15-20 to 30-45 Ma), El Mamey Fm., Dominican Republic, Province of Santiago, flowers (corollas with stamens and styles). Poinar and Struwe, 2016.

LORANTHACEAE [see also *Azolla*, Bowman et al., 2014]. Liu et al. (2018)- nuclear and chloroplast DNA sequences: 'The crown group of Loranthaceae was estimated to originate in Australasian Gondwana during the Paleocene to early Eocene (59 Ma), converting from root parasitic to aerial parasitic trophic mode ca. 50 Ma during the Eocene climatic optimum. The African and Eruopean members were derived from Asiatic lineage. Trophic mode conversion corresponds to rapid radiation of many bird families—important agents for long-distance dispersal in the Cenozoic' (p. 199).

Arceuthobium- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Cranwellia striata- Late Cretaceous (Coniacian to Campanian), Antarctic Peninsula, pollen; Poole, 2005.

LYTHRACEAE (Graham & Graham, 1971; S. Graham, 2013).

Adenaria- Pliocene, Colombia, seeds (S. Graham, 2013, p. 53).

Antholithus heimiaformis- Miocene, Yumuri Gorge Fl., Cuba, flower; Berry, 1939; rejected as a flower of *Heimia*, relationship unknown, S. A. Graham, 2013, p. 72.

Crenea (*Verrutricolporites*)- see S. Graham, 2013, pp. 55-57.

Cuphea (see S. Graham, 2013, pp. 57-59)- Miocene part of Mio-Pliocene Citronelle Fm., AL, pollen, Leopold, unpublished, in Graham & Graham, 1971, p. 335; Miocene,

Pichucalco Fl., Chiapas, Mexico, pollen, Palacios Chavez & Rzedowski, 1993; middle Pliocene, Paraje Solo Fm., Veracruz, Mexico, pollen, Graham, 1976.

Decodon tiffneyi- Late Cretaceous (late Campanian), Cerro del Pueblo Fm., Coahuila, Mexico, seed; Estrada-Ruiz et al., 2009; *D. allenbyensis*, middle Eocene, Allenby Fm., Princeton Chert Fl., British Columbia, Canada, roots, stems, leaves, fruits, seeds; Cevallos-Ferriz & Stockey, 1988; Little & Stockey, 2003, 2006. *D. brownii*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997. *D.* sp.- middle Eocene (44 Ma), Clarno Fm., OR, fruits; Manchester, 1994. See also S. Graham, 2013, pp. 59-63.

Duabanga allenbyensis- middle Eocene, Allenby Fm., Princeton Chert Fl., British Columbia, Canada, leaf; Little et al., 2004.

Hemitrapa- see S. Graham, 2013, p. 72.

Lafoensia- Quaternary, Panama, pollen; Bartlett & Barghoorn, 1973. Pleistocene-Holocene, Brazil, pollen, Barberi et al., 2000. See also S. Graham, 2013, p. 72.

Lawsonia-like, middle Eocene, Allenby Fm., Princeton Chert Fl., British Colombia, Canada, seed; Cevallos-Ferriz & Stockey, 1988; relationship to *Lawsonia* unconfirmed. See also S. Graham, 2013, pp. 75-76.

Lythrum elkensis- Late Cretaceous (Lower Campanian), Eagle Fm., Montana Group, WY, pollen, Grímsson et al., 2011; "This is the earliest record of *Lythrum* worldwide" (p. 1803); also reports pollen of *L. wilhelmii* from the late Miocene (upper Pannonian, ca. 9.5 Ma), Austria. See S. Graham, 2013, pp. 76-78.

Microdiptera- see S. graham, 2013, pp.78-79.

Peplis eaglensis- Late Cretaceous (Lower Campanian; 82-81 Ma), Montana Group,

Eagle Fm., WY, pollen, Grimsson et al., 2011: "This is the earliest record of *Pemphis* worldwide" (p. 1809); also reports pollen of *P. yakuitana* from the Late Cretaceous (Upper Campanian/lower Maastrichtian; 72-68 Ma), Siberia, Russia. See also S. Graham, 2013, p. 81.

Quereuxia- See S. Graham, 2013, p. 84.

Shirleya (…"an extinct member of the Lythraceae and closely related in the family to modern *Lagerstroemia*; S. Graham, 2013, p. 88). Middle Miocene, Yakima Canyon Fl., WA, fruits and seeds; Pigg & DeVore, 2005; Pigg & Wehr, 2002.

Striasyncolpites zwaardi (pollen form-genus of *Cuphea*), middle Miocene to Recent, Trinidad, Germeraad et al., 1968; Miocene to Pliocene, northeastern Brazilian continental shelf, Pares Regali et al., 1974.

Trapa americana- late Miocene (Clarendonian, 12 Ma), Ironside Fm., OR; Retallack, 2004. cf. *Trapa*- late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005. See also S. Graham, 2013, pp. 92-103.

Tripartisemen bonesii- see S. Graham, 2013, p. 103.

MAGNOLIACEAE [late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014].

Liriodendron (four-lobed *Liriodendron*)- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002. *L.* sp.- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007.

Liriodendrites bradacii- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Liriodendroxylon multiporosum- middle Eocene (44 Ma), Clarno Fm., OR, wood;

Wheeler & Manchester, 2002.

Magnolia muldoonae, M. paroblonga, M. tiffneyi- middle Eocene (44 Ma), Clarno Fm., OR, infructescence, seeds; Manchester, 1994. *M. pageae*- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002. *Magnolia* sp.- late Eocene (36 Ma), lower John Day Fm., OR, seeds casts, Manchester & McIntosh, 2007; Miocene (15-6 Ma), Iceland, Grimsson & Denk, 2007.

Magnoliaceoxylon angulata, M. cutleri, M. longiradiata- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

MAGNOLIIDAE- see Crepet & Nixon, 1994, Turonian *Magnoliidae*.

Araripia florifera (cf. Laurales)- Lower Cretaceous (Aptian, possibly Albian; now late Aptian), Crato Fm., Brazil, axes, attached leaves, flower buds; Mohr & Eklund, 2003.

Archaeanthus linnenbergeri- Middle Cretaceous (uppermost Albian- mid-Cenomanian), Dakota Fm., KS, fruit linked with perianth parts (*Archaepetala beekeri, A. obscura*), bud scales (*Kalymmanthus walkeri*), and leaves (*Liriophyllum kansense, L. populoides*); Dilcher & Crane, 1984.

cf. *Detrusandra* (Magnoliales)- Late Cretaceous (late Santonian), Buffalo Creek Member, Gaillard Fm., Allon Fl., GA., flowers; Herendeen et al., 1999.

Endressinia brasiliana- Lower Cretaceous (late Aptian), Crato Fm., Brazil, axes, leaves, flowers; Mohr & Bernardes-de-Oliveira, 2004.

Lesqueria elocata- Middle Cretaceous (uppermost Albian- mid-Cenomanian), Dakota Fm., KS, and Woodbine Fm., northeastern TX, fruiting axis; Crane & Dilcher, 1984.

MALPIGHIALES- Xi et al. 2012: 'Using plastid genes demonstrate rapid rise during the mid-Cretaceous'. Ruhfel et al., 2016: 'Dispersal rather than vicariance largely explains Gondwana distribution of ancient tropical clusioid plant clade (Malpighiales).'

MALVACEAE

Carvalho, et al. (2011): "We describe fossil leaves of Malvoideae from the middle-late Paleocene Cerrejón Formation in Colombia, which contains evidence for the earliest known neotropical rainforest. Fossil pollen from the same formation was also assessed. The [56] leaf compressions, the oldest for Eumalvoideae, indicate a minimum divergence time of 58-60 Ma, older than existing estimates from molecular analyses of living species. The abundance of eumalvoid leaves and of bombacoid pollen in the middle Paleocene of Colombia suggests that the Malvatheca group (Malvoideae + Bombacoideae) was already a common element in neotropical forests and does not support an Australasian origin for Eumalvoideae" (p. 1337).

Baumannipollis- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Bombacacacidites annae- middle to late Paleocene (58-60 Ma), Cerrejón Fm., Ranchería Basin, no. Colombia, pollen; Carvalho et al., 2011.

Chattawaya paliforme- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002: ["Manchester (1980) found the closest resemblance to some species of the extant *Pterospermum*, although the characteristic winged seeds of that modern genus have not been found as fossils" p. 91].

Craigia- Eocene, TN, fruit; Manchester & O'Leary, 2010: ["…widespread in the Tertiary of the Northern Hemisphere…traced back to the Eocene in eastern Asia and western North America (Kvaček, 2005)"; reexamined type of *Ptelea eocenica* (Berry,

1930)…similar to fruits of extant *Craigia* and *Maxwellia* (p. 73)].

Florissantia quilchenensis- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, flowers, Dillhoff et al., 2005; middle Eocene, Republic Fl., WA, Manchester, 1992.

Fremontia (*Fremontodendron*)- see Sterculiaceae.

Gossypium- Patterson et al., 2012: "Here we show that an abrupt five- to sixfold ploidy increase approximately 60 million years (Myr) ago, and allopolyploidy reuniting divergent *Gossypium* genomes approximately 1-2 Myr ago, conferred about 30-36-fold duplication of ancestral angiosperm (flowering plant) genes in elite cottons (*Gossypium barbadense*), genetic complexity equaled only by *Brassica* among sequenced angiosperms." "A-genome diploids native to Africa and Mexican D-genome diploids diverged ~5-10 Myr ago. They were reunited ~1-2 Myr ago by trans-oceaanic dispersal of a maternal A-genome propagule resembling *G. herbaceum* to the New World, hybridization with a native D-genome species resembling *G. raimondii*, and chromosome doubling. The nascent A_tD_t allopolyploid spread throughout the American tropics and subtropics, diverging into at least five species; two of these species (*G. hirsutum* and *G. barbadense*) were independently domesticated to spawn one of the world's largest industries (textiles) and become a major oilseed." "Shortly after its divergence from an ancestor shared with *Theobroma cacao* at least 60 Myr, the cotton lineage experienced an abrupt five- to sixfold polyploidy increase" (p, 423). *G.* sp.- late Miocene, Vasa Park Fl., King Co., WA., leaf, Dillhoff et al., 2014.

Guazumaoxylon miocenica- lower Miocene, Cucaracha Fm., Gaillard Cut, Canal Zone, Panama, wood, aff. extant *Guazuma* (Subfam. Byttnerioideae); Rodríguez-Reyes et al.,

2014.

Javelinoxylon multiporosum- Late Cretaceous, Javelin Fm., Big Bend National Park, TX, wood; Wheeler et al., 1994. *J. weberi*- Late Cretaceous (late Campanian-early Maastrichtian), Olmos Fm., Coahuila, Mexico, wood; Estrada-Ruiz et al., 2007.

Malvaceous pollen- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

Malvaciphyllum macondicus- middle to late Paleocene (58-60 Ma), Cerrejón Fm., Ranchería Basin, no. Colombia, leaves, aff. extant Eumalvoideae clade of Malvoideae (*Hibiscus, Wercklea, Malvaviscus*); Carvalho et al., 2011.

Malvacipollis argentina- Cullen Fm., late Eocene to middle Oligocene, NE Isla Grande de Tierra del Fuego, Argentina, pollen; Zamaloa & Romero et al., 1990.

Palaeoaster cordatum- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Periplanetoxylon panamense- lower Miocene, Cucaracha Fm., Gaillard Cut, Canal Zone, Panama, wood, aff. extant *Pentaplaris* (Subfam. Malvoideae); Rodríguez-Reyes et al., 2014.

Triplochitioxylon oregonensis- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

MELASTOMATACEAE- Renner et al., 2001: "Based on fossils, ranges of closest relatives, tree topology, and calibrated molecular divergences, Melastomataceae initially diversified in Paleocene/Eocene times in tropical forest north of the Tethys. Their earliest (Eocene) fossils are from northeastern North America, and during the Oligocene and Miocene melastomes occurred in North America as well as throughout

Eurasia. They also entered South America, with earliest (Oligocene) South American fossils representing Merianieae. One clade (Melastomeae) reached Africa from the neotropics 14-12 million years ago and from there spread to Madagascar, India, and Indochina" (p. 1290). "Earliest fossils are Eocene leaves from northwestern North America (Hickey, 1977; Wehr and Hopkins, 1994), an Oligocene leaf from Andean Colombia (Huertas, 1977), and Miocene seeds from throughout Eurasia (Dorofeev, 1960, 1963, 1988; Collinson and Pingen, 1992; Dyjor et al., 1992; Fairon-Demaret, 1994; Mai, 1995, 2000). Pollen records are much younger" (p. 1291; but see Graham, 2010, p. 497-498; Morley & Dick, 2003).

Melastomeae- Michelangeli et al. (2013): "The clade formed by *Tibouchina* and allies appears to have arisen in savannas in lowland South America and later expanded to forest, campo, and high Andean biomes" (p. 38).

Miconia- late Pliocene-Quaternary (ca. 2.7 Ma), High Plain Bogotá, Colombia, pollen; Hooghiemstra, 1995.

Rhexia- Renner & Meyer, 2001: "Age estimates obtained were 22 million years ago (Myr) for the divergence of *Rhexia* from its sister group, 12 Myr for the dispersal of Melastomeae from the New World to West Africa, and 1 Myr for the diversification of *Melastoma* in Southeast Asia" (p. 1315).

MELIACEAE- Muellner et al. (2006, p. 241): "The fossils of *Ailanthus confucii* [Simaroubaceae, outgroup] have been dated to be 52 million years (my) old (Early Eocene; Corbett and Manchester, 2004)…*Toona* [Meliaceae], from the London clay, which also dates to the Early Eocene and therefore is of at least 49 my of age (DeVore et al., 2005; Reid and Chandler, 1933)."

Aglaia- Mio/Pliocene, India (K. B. Pigg, personal communication, 2005 to Muellner et al., 2006).

Carapoxylon- middle Miocene, Bavaria (Selmeier, 1983).

Cedrela merrillii- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf, seed; Meyer & Manchester, 1997. *C.* sp.- Muellner et al., 2006, pp. 242-243: early Eocene, Chalk Bluffs Fl., western central Sierra Nevada, CA, Leopold, 1984, MacGinitie, 1941, in Millar, 1996); Middle Eocene, Kisinger Lake, Fremont, WY (MacGinitie, 1974); Late Eocene, Florissant Fl., CO (MacGinitie, 1953, Manchester, 2001, Meyer, 2003); late Eocene (36 Ma), lower John Day Fm., OR, fruits, Manchester & McIntosh, 2007; Eocene, Wind River, WY (MacGinitie, 1974); Eocene, Kamchatka, USSR (K. B. Pigg, personal communication, 2005 to Muellner et al., 2006); Late Oligocene, Grays Ranch, Crook, OR (Meyer & Manchester, 1997); Oligocene, MT (Becker, 1961; 1962- lists *Cedrela*); middle Miocene, Tehachapi Fl., Sierra Nevada, CA (Axelrod 1939; Chaney, 1944); middle and late Miocene, OR, ID (Chaney & Axelrod, 1959), NV (Axelrod, 1985, 1991); late Miocene (now middle Pliocene), Paraje Solo Fm., Veracruz, Mexico, pollen, Graham, 1976; Miocene, Hungary (Mai, 1995); early Miocene La Quinta Fm., Chiapas, Mexico, pollen, Graham, 1999; Miocene, Gatun Fm., central Panama, pollen, Graham, 1991. cf. *C.*- Pliocene, Amazonas Fm., w. Amazon Basin, Iquitos, Peru, wood; Pons & de Franceschi, 2007.

Cedrela or *Toona* seeds- latest Eocene (34.1 Ma), Florissant Fl., CO; Manchester, 2001.

Chisochetonoxylon- Miocene, Birbhum District, West Bengal, India (Ghosh & Roy, 1979).

Entandrophragma- Miocene, Kenya, Chesters, 1957 in Mabberley et al., 1995.

Guarea ceratops, Late Cretaceous, Lance and Hell Creek Fms., WY, fruits; Graham, 1962. *G.* sp.- Oligocene, San Sebastaian Fm., Puerto Rico, pollen, Graham & Jarzen, 1969; early Miocene, La Quinta Fm., Chiapas, Mexico, pollen, Graham, 1999; middle Miocene, Pebas Fm., w. Amazon Basin, Iquitos, Peru, wood, Pons & De Franceschi, 2007; middle Pliocene, Paraje Solo Fm., Veracruz, Mexico, pollen, Graham, 1976; Quaternary, High Plain, Bogotá, Colombia, pollen, Hooghiemstra, 1984.

Melia- lower Miocene, Poland (K. B. Pigg, pers. comm., 2005 to Muellner et al., 2006); middle Miocene, Yakima Canyon Fl., WA, (K. B. Pigg, pers. comm., 2005 to Muellner et al., 2006). *M. yakimaensis*- middle Miocene, Columbia River Basalt Group, central Washington state, U.S.A., fruits; Pigg et al., 2014.

Meliaceoidites- late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005.

Toona (Muellner et al., 2006, p. 243): early Eocene, London Clay, England (Collinson, 1983; Reid & Chandler, 1933), recently re-investigated by noninvasive CT-scanning technique (DeVore et al., 2005); middle Eocene, AK, (K. B. Pigg, pers. comm., 2005 to Muellner et al., 2006).

Trichilia- lower Miocene, Cameroon; Salard-Cheboldaeff, 1978.

MELIOSMACEAE (see SABIACEAE)

MENISPERMACEAE- Doria et al., 2008: “The oldest record identified with some confidence is an endocarp from the Turonian (Upper Cretaceous, 91 Ma) of central Europe (Knobloch and Mai, 1984, 1986), but fossil leaves found in North America (Fontaine, 1889; Berry, 1916; Hollick, 1927; Seward, 1927; Hollick and Martin, 1930; Bell, 1956; Doyle and Hickey, 1976) and Asia (Takhtajan, 1974; Spicer et al., 2002)

suggest that the family can be traced to the Early Cretaceous. Fossil pollen has been widely reported since the Early Cretaceous in many different geographic areas (Table 3). The tropical fossil record of Menispermaceae is very sparse and consists of endocarps (Chesters, 1957) and leaves (Jacobs and Kabuye, 1987) from the Miocene of Kenya, leaves from the Eocene of Borneo (Andrews, 1970) [supplements by Blazer, 1975, and Watt, 1982], and pollen from the Miocene of Tunisia (Méon and Tayech, 1986) and Taiwan (Huang, 1980; Song et al., 2004) and Pleistocene of Ethiopia (Bonnefille et al., 1987). In South America the fossil record of the family is reduced to fossil leaves from the Paleocene of Argentina (Iglesias et al., 2007) and the Eocene (De Lima and Salard-Cheboldaeff, 1981) and Pliocene of Brazil (Dolianiti, 1949; Mello et al., 2000), one liana fossil wood probably related to Ranunculales from the Miocene of Argentina (Lutz and Martínez, 2007), and fossil pollen from the Oligocene to Recent of British Guiana (van der Hammen and Wijmstra, 1964) and the Miocene of Suriname (Amstelveen, 1971)" (pp. 955-956). Late Eocene (36 Ma), John Day Fm., OR, fruits; Manchester & McIntosh, 2007. Wefferling et al., (2013): "…menispermaceous endocarps appear often in the fossil record and indicate the presence of a wet forest ecosystem" (p. 883); Two recent studies explored divergence time estimates incorporating fossil data and biogeographic patterns (Jacques et al, 2011; Wang et al., 2012) (p. 883); see also pp. 883-884, 901 (Fossil record and biogeography- The discovery of northern South American Paleocene fossil pushes back the crown age of the *SPACC* clade as presented in Wang et al. (2012) by 6-7 million years to ~60 Ma (Herrera et al., 2011) and raises the possibility of a Gondwanan center of diversification for at least some Menispermoideae" (p. 901). For a summary of the global fossil record of the family

taking into account the unconfirmed nature of many older identifications see Jacques (2009, especially table 2 and fig. 1).

Anamirta leiocarpa- middle Eocene (44 Ma), Clarno Fm., OR, fruit; Manchester, 1994.

Atriaecarpum clarnense- middle Eocene (44 Ma), Clarno Fm., OR, endocarps; Manchester, 1994.

Calycocarpum crassicrustae- middle Eocene (44 Ma), Clarno Fm., OR, endocarps, locule casts; Manchester, 1994. *C.* sp.- middle Eocene, Republic Fl., WA, fruit; Wehr & Manchester, 1996.

cf. *Canticocculus*- Paleocene, Sentinel Butte Fm., Almont, ND, fruits; Crane et al., 1990, 2007, Pigg & DeVore, 2010.

Chandlera lacunosa- middle Eocene (44 Ma), Clarno Fm., OR, endocarps; Manchester, 1994.

Curvitinospora formanii- middle Eocene (44 Ma), Clarno Fm., OR, locule cast; Manchester, 1994.

Davisicarpum limacioides- middle Eocene (44 Ma), Clarno Fm., OR, endocarp; Manchester, 1994.

Diploclisia auriformis- middle Eocene (44 Ma), Clarno Fm., OR, fruit, locule casts; Manchester, 1994.

Eohypserpa scottii- middle Eocene (44 Ma), Clarno Fm., OR, locule casts; Manchester, 1994.

Menispermites cerrejonensis, M. cordatus, M. guajiraensis, M. horizontalis- middle to Late Paleocene, Cerrejón Fm., Guajira, Colombia, leaves; Doria et al., 2008.

cf. *Menispermum*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR,

endocarp; Meyer & Manchester, 1997.

Menispina evidens- middle to late Paleocene, Bogatá Fm., Colombia, endocarps; Herrera et al., 2011.

Odontocaryoidea nodulosa- middle Eocene (44 Ma), Clarno Fm., OR, endocarps, locule casts; Manchester, 1994.

Palaeoluna bogotensis- middle to late Paleocene, Bogatá Fm., Colombia, endocarps; Herrera et al., 2011.

Palaeosinnomenium venablesii- middle Eocene (44 Ma), Clarno Fm., OR, endocarps, locule casts; Manchester 1994.

Stephania palaeosudamericana- middle to late Paleocene, Cerrejón Fm., Colombia, endocarps; Herrera et al., 2011.

Thanikaimonia geniculata- middle Eocene (44 Ma), Clarno Fm., OR, locule cast; Manchester, 1994.

cf. *Tinomiscium* sp.- late Paleocene, Almont Fl., ND, fruit; Pigg & DeVore, 2010 (pers. comm. from Manchester).

Tinomiscoidea occidentalis- middle Eocene (44 Ma), Clarno Fm., OR, locule casts; Manchester, 1994.

Tinospora elongata, T. hardmanae- middle Eocene (44 Ma), OR, locule casts, endocarps; Manchester, 1994.

MONIMIACEAE [asee also *Azolla*, Bowman et al., 2014]

Hedycaryoxylon tambourissoides- Late Cretaceous (Coniacian to Campanian), Antarctic Peninsula, wood, pollen; Poole et al., 2005.

Monimiophyllum callidentatum- early Eocene, Laguna del Hunco Fl. (52.2 Ma), Chubut

Province, Patagonia, Argentina, leaves (cf. extant *Wilkiea*); Knight and Wilf, 2013.

MONOCOTYLEDONS- (Mohr & Rydin, 2002, pp. 335-336; includes review of fossil monocotyledons): "The oldest flowering organs containing *in situ* pollen which can be putatively placed in the monocots, possibly with affinities to the Alismatales, were described from the Barremian to Aptian of Portugal (Friis et al., 2000). The North American fossils from the Aptian of the Potomac Group, such as *Acaciaephyllum* are considered to be ambigious (Gandolfo et al., 2000). But seeds which resemble *Epipremnum* (Araceae or Alismatales) are known from the Albian of North America (Herendeen & Crane 1995). Unequivocal flowers of monocots are from the Turonian (Gandolfo et al., 1998) of North America (New Jersey). Cretaceous leaves, *Zingiberopsis*, which are considered to belong to the Zingiberaceae, are from the …Maastrichtian of Colorado (Hickey & Peterson, 1978). Seeds of the extinct genus *Spirematospermum* (Musaceae) have been recovered from…the Campanian of North America (Friis, 1988)." Mohr & Rydin (2002) include a general review of fossil monocotyledons; see also Stockey (2006).

Trifurcatia flabellata (monocotyledon)- Lower Cretaceous, Crato Fm., northeast Brazil, shoot fragments with leaves; Mohr & Rydin, 2002.

MORACEAE

Ficus-like- middle Eocene, Caliborne Group, TN, leaves; Dilcher & Lott, 2005.

Morus-type pollen- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

Pseudolmedia sp.- middle Eocene, Claiborne Group, TN, leaves; Dilcher & Lott, 2005.

MUSACEAE [see discussion in Graham, 2010, p. 387 re *Musa/Ensete*].

Ensete oregonense- middle Eocene (44 Ma), Clarno Fm., OR, seeds; Manchester, 1994.

E. sp.- middle Eocene, Republic Fl., WA, fruits with seeds; Wehr & Manchester, 1996.

Musopsis/Musophyllum- late Paleocene/early Eocene, Greenland, leaf; Boyd, 1992.

MYRICACEAE- see Sims et al. (1999), 'higher' hamamelids (Juglandaceae, Rhiopteleaceae, Myricaceae, Betulaceae).

Comptonia columbiana- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage, Dillhoff et al., 2005; middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaves, Axelrod, 1998; middle Eocene, Republic Fl., WA, leaves, Wolfe & Wehr, 1987; Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf, Meyer & Manchester, 1997. *C. hesperia*- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007.

Myrica sp.- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Striatricolporites- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Triatropollenites subtriangulus (*Myrica*)- lae Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, pollen; Daly et al., 2011.

MYRTACEAE- Sytsma et al., 2004: "the results indicate that the PHMV [Psiloxylaceae, Heteropyxidaceae, Myrtaceae, Vochysiaceae] differentiated during the late Cretaceous. The African lineage of Vochysiaceae is nested within a South American clade and probably arose via long-distance dispersal in the Oligocene at a time when the Atlantic had already rifted 80 m.yr. at the equatorial region. The African/Mascarene Island families, most closely related to Myrtaceae, differentiated during the late Eocene, with subsequent but recent long-distance dispersal from Africa

to the Mascarenes" (p. 585).

Amomyrtus meli- last interglacial (MIS 5e- called Valdivia in southern Chile), Mancera interglacial sequence, Mancera Island, Chile, leaves; Astorga & Pino, 2011.

Eucalyptus sp.- early Eocene (ca. 51.9 Ma), Laguna dele Hunco Fl., Chubut Province, Argentina, leaves, infructescences, capsules, flower buds, single flower; Gandolfo et al., 2011: "These are the only illustrated *Eucalyptus* fossils that are definitely Eocene in age, and the only conclusively identified extant or fossil eucalypts naturally occurring outside of Australasia and adjacent Mindanao. Paleoecological data indicate that the Patagonian *Eucalyptus* dominated volcanically disturbed areas adjacent to standing rainforest surrounding an Eocene caldera lake".

Eugenia[*/Myrcia*]- late Pliocene-Quaternary (ca. 2.7 Ma), High Plain Bogotá, Colombia, pollen; Hooghiemstra, 1995. (see also Oliveira Bünger et al., 2016).

Fulleroxylon armendarisense- Late Cretaceous (Maastrichtian), McRae Fm., NM, wood; Estrada-Ruiz et al., 2012.

Luma apiculata- last interglacial (MIS 5e- called Valdivia in southern Chile), Mancera interglacial sequence, Mancera Island, Chile, leaves; Astorga & Pino, 2011.

Myceugenelloxylon antarcticus- Late Cretaceous (late Maastrichtian), mid-early Paleocene, middle Eocene, Antarctic Peninsula, wood, Poole et al., 2005.

Myrceugenia- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

Myrcia- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves, Gayó et al., 2005; middle Eocene, Claiborne Group, TN, leaves, Dilcher & Lott, 2005.

Lucas et al., 2011 (pp. 931-932): "…tentatively assume eastern tropical South America

to be the ancestral area of *Myrcia* s.l. …ancestors of *Myrcia* s.l. could have migrated north and east through the tropical forests that covered the continent to 45ºS during the late Paleocene and Eocene (~50 Ma; Landrum, 1981). Raven and Axelrod (1974) suggest that fleshy-fruited Myrtaceae subsequently dispersed farther northward, eventually reaching Central America, the West Indies, and relatively northern parts of North America, such as British Columbia, where fossil *Paleomyrtinae* is found (Pigg et al., 1993). …undergone disjunction…(Ortiz-Jaureguizar and Cladera 2006) over Patagonia, Bolivia, and Peru (55-24 Ma) and in the Amazon (26-11 Ma). This is in line with an age of Myrteae of ~32 Ma, as suggested by Biffin et al. (2010)."

Myrtaceae- Late Cretaceous (Coniacian to Campanian), Antarctic Peninsula, pollen; Poole et al., 2005.

Myrtaceidites- Late Cretaceous (late Maastrichtian), lower middle Eocene, Antarctic Peninsula, pollen, Poole et al., 2005. *M. verrucosus, M.* sp. (cf. *Myrceugenia*)- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Paleomyrtinaea sp.- middle Eocene, Republic Fl., WA, fruit, Wehr & Manchester, 1996; Williston Basin, Almont, Beicegel Fls., ND, SD, MT, adjacent Canada, fruits, seeds, Crane et al., 1990, Pigg et al., 1993, Pigg & DeVore, 2010.

?*Psidium*- Paleocene, Sentinel Butte Fm., Almont, ND, fruits, seeds; Crane et al., 1990; Pigg et al., 1993.

MYRTACEOUS AFFINITY

Syzgioides americana- middle Eocene, Parachute Member, Green River Fm., CO, compressed twigs showing attachment of leaves, axillary panicles of flowers and fruits; Manchester et al., 1998.

NELUMBONALES

Nelumbites extenuinervis, *N*. cf. *N. minimus*- Lower Cretaceous (upper Albian), Potomac Group, VA, leaves; Upchurch et al., 1994.

NELUMBONACEAE

Exnelumbites callejasiae (and *E.* morphotypes 1, 2)- Late Cretaceous (Campanian-Maastrichtian), Olmos Fm., Coahuila, Mexico, Jose Creek Member of the McRae Fm., NM, leaves; Estrada-Ruiz et al., 2011.

Nelumbium montanum- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002; Paleocene Member of Fort Union Fm., ND, SD, megaflora, Johnson, 2002.

Nelumbo puertae- Upper Cretaceous (Campanian-Maastrichtian), La Colonia Fm., Chubut Province, Argentina, Patagonia, leaves and associated *Nelumbo*-like reproductive structures; Gandolfo & Cúneo, 2005 (fossil record for the family is discussed on p. 175-176). *N.* sp.- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002; *N.* (rhizome)- Paleocene, Ludlow Member, Fort Union Fm., ND, SD, megaflora, Johnson, 2002.

NOTHOFAGACEAE [see also *Azolla*, Bowman et al., 2014]

Nothofagus- Manos (1997): [based on a study of 22 species representing the four subgenera and related outgroups, nuclear ribosomal DNA sequences, "…tropical *Nothofagus* (subgenus *Brassospora*) of New Guinea and New Caledonia are strongly supported as sister to cool-temperate species of South America (subgenus *Nothofagus*)" p. 1137]. *Nothofagus betuloides*- early Miocene, Tierra del Fuego, Argentina, leaves; Gandolfo & Romero, 1990; see also Hill, 2001; Hill & Read, 1991;

Hill & Jordan, 1993; Swenson & Hill, 2001; Dettmann et al., 1990. Fossil pollen = *Nothofagidites*. "The earliest on-land occurrences of *Nothofagidites* cited for South America are *N. rocaensis* from the middle Maastrichtian Jagűel Formation of Río Negro Province (~70 Ma) and *N. dorotensis* from the late Maastrichtian-early Paleocene Cerro Doretea Formation of Santa Cruz Province (~65 Ma). These are ~13.5 Ma or more later than the age cited for Australasia and Antarctica" (Graham, 2010, p. 496; see also Notes, p. 2). *N. dombeyi* (leaves), *N.* sp. (wood)- last interglacial (MIS 5e- called Valdivia in southern Chile), Mancera interglacial sequence, Mancera Island, Chile; Astorga & Pino, 2011.

Nothofagidites- late Eocene, SHALDRIL core, James Ross Basin, Wendell Sea (37-33.7 Ma); *Nothofagidites americanus, N. anisoechinatus, N. dorotensis, N. flemingii, N. menziesii, N. nanus, N rocaenis, N. saraensis*- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Nothofagoxylon corrugatus, N. palaeoalessandri, N. ruei, P. sclariforme- middle Eocene, Antarctic Peninsula, wood, leaf; Poole et al., 2005. *N. corrugatus, N. ruei, N. scalariforme*- early-late Paleocene, lower middle Eocene, Antarctic Peninsula, wood; Poole et al., 2005. *N. kraeuselii, N. sclariforme, N. ruei, N.corrugatus, N. triseriatum*- mid-early Paleocene, Antarctic Peninsula, wood; Poole et al., 2005. *N. aconcaguaense, N. corrugatus, N. kraeuseli, N. ruei, N. sclariforme*- Late Cretaceous (late Maastrichtian), Antarctic Peninsula, wood; Poole et al., 2005. *N. scalariforme*- Late Cretaceous (Coniacian to Campanian), Antarctic Peninsula, wood; Poole et al., 2005.

NYMPHAEACEAE/NYMPHAEALES/NYMPHAEALEAN- see Borsch & Soltis (2008; Nymphaeales—The First globally diverse clade? Nymphaeales Symposium, Taxon 57: 1051-1158).

Aquatifolia fluitans (cf. Nymphaeaceae)- Lower Cretaceous (Albian), Dakota Fm., Hoisington III locality, Barton Co., KS, leaves; Wang & Dilcher, 2006.

cf. *Nelumbo*- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Nuphar wutuensis- late Paleocene, Almont, Beicegel Fls., ND, Chen et al., 2004; Pigg & DeVore, 2010. *N.* sp.- middle Eocene, Republic Fl., WA, seeds, stigmatic disc, Wehr & Manchester, 1996; latest Eocene (34.1 Ma), Florissant Fl., CO, pollen, Leopold & Clay-Poole, 2001. *N.* sp.- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005. cf. *Nuphar* (fruit, seed), *Nuphar* sp. (rhizome)- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR; Meyer & Manchester, 1997. cf. *Nuphar* sp.- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007.

Nymphaea, N. sp.- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Nymphaeaceae gen. et sp. indeterminate- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fm., OR, leaf; Meyer & Manchester, 1997.

Nymphaeites sp.- middle Eocene (45 Ma), Thunder Mountain Fl., ID, impression of root scars; Axelrod, 1998.

Pluricarpellatia peltata (nymphalealean)- Lower Cretaceous, Crato Fm., NE Brazil, roots, cordate peltate leaves, flowering structures with seeds; Mohr et al., 2008.

Susiea newsalemae- late Paleocene, Almont, Beicegel Fl.s, ND, seeds, Taylor et al.,

2006, Pigg & DeVore, 2010.

NYSSACEAE (see Cornaceae)

OCHNACEAE

Ochna sp.- late Paleocene, Almont, Beicegel Fls., ND, Crane et al., 1990, Pigg et al., 2005, Pigg & DeVore, 2010.

Paleochna tiffneyi- fruits, late Paleocene, Almont/Beicegel Creek Flora, late Paleocene, North Dakota.

Quiinoideae- Amazonia, 'Molecular dating indicated the Quiinoideae originated during the late Cretaceous, whereas crown group taxa started to diverge at the Eocene-Oligocene boundary' (Schneider and Zizka, 2017).

OLACACEAE

Anacolosidites sectus- Late Cretaceous (late Maastrichtian), Antarctic Peninsula, pollen, Poole et al., 2005. *A.* sp.- lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005.

OLEACEAE (see also Brassicaceae, *Tricolpopollenites*)

Fraxinus dayana- late Miocene (Clarendonian, 12 Ma), Ironside Fm., OR, samara; Retallack, 2004. *F. edentus*- middle Miocene, Mint Canyon Fl. (preliminary study), so. CA; Axelrod, 1940. *F. stenocarpa*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, samara; Axelrod, 1998a. *F.* sp.- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, fruit, Meyer & Manchester, 1997; Miocene (15-6 Ma), Iceland, Grimsson & Denk, 2007; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014. *F.*-type pollen, latest Eocene (34.1 Ma), Florissant Fl., CO; Leopold & Clay-Poole, 2001.

Oleaceae leaf morphotype- middle Eocene, Claiborne Group, TN; Dilcher & Lott, 2005.

ONAGRACEAE- for a record from the Miocene of China see Grímsson et al., 2012; for a review of the fossil record of the family in Australia see Martin (2003; other records are discussed beginning on p. 590 and listed in table 5): "The oldest fossils of the family Onagraceae are Late Cretaceous in age and are found in Brazil, California and Maryland (Table 5). The Californian Campanian-Maastrichtian fossil is generally similar to *Oenothera* and *Galpinsia* (= *Oenothera*) and almost identical to the Upper Cretaceous specimens from Maryland (Chmura 1973). Photographs show that they are indeed similar and the likeness to *Oenothera* is plausible. The Maastrichtian specimen from Brazil is identified with the Eocene specimens of Columbia (Pares Regali et al., 1974), and the Columbian specimen is identified with *Ludwigia* (Gonzalez Guzman 1967). The photographs of the Eocene specimens clearly show the characteristic ectoaperture of *Ludwigia*. The Brazilian specimen generally looks like *Ludwigia*, with a suggestion of an ectoaperture, but it is not clear. It is clear, however, that the South American specimens are quite different to the North American Late Cretaceous grains. The family had thus diversified into at least two lineages in the Late Cretaceous" (pp. 590-593). [Occurrences elsewhere in the world are discussed on p. 593 et seq.]. Undetermined genus- late Miocene, Vasa Park Fl., King Co., WA, Dillhoff et al., 2014.

Colombipollis sp.- Upper Cretaceous, Mito Juan Fm., western Venezuela, pollen; Pocknall & Jarzen, 2009- the authors list other families with viscin threads.

Corsinipollenites atlantica- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012. *C.* sp.- Paleocene, Los Cuervos Fm., western Venezuela, pollen; Pocknall & Jarzen, 2009.

Crassiorites australis- late Eocene to middle Oligocene, Cullen Fm., Isla Grande de Tierra del Fuego, Argentina, pollen; Zamaloa & Romero, 1990 (pp. 130-131).

Fuchsia- Berry et al. (2004): "An ultrametric molecular clock analysis (all minimum dates) places the split between *Fuchsia and Ciraea* at 41 million years ago (mya), with the diversification of the modern-day lineages of *Fuchsia* beginning at 31 mya. The South Pacific *Fuchsia* lineage branches off around 30 mya, consistent with fossil records from Australia and New Zealand. The large Andean section *Fuchsia* began to diversify around 22 mya, preceded by the divergence of the Caribbean *F. triphylla* at 25 mya. The Brazilian members of section *Quelusia* separated from the southern Andean *F. magellanica* around 13 mya, and the ancestor of the Tahitian *F. cyrtandroides* split off from the New Zealand species of section *Skinnera* approximately 8 mya" (p. 601).

Onagraceous flower- latest Eocene (34.1 Ma), Florissant Fl., CO; Manchester, 2001.

Semeiandra aff. *Xylonagra*- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

Trivestibulopollenites sp. (cf. *Oenothera*; Martin, 2003, p. 590)- Late Cretaceous (Campanian-Maastrichtian), Uhalde Fm., western San Joaquin Valley, CA, pollen; Chmura, 1973.

ORCHIDACEAE

Meliorchis caribea (Subtribe *Goodyerinae*)- Miocene, Dominican amber, Dominican Republic, pollinarium attached to the mesoscutellum of an extinct stingless bee, *Prolebeia dominicana*; Ramírez et al., 2007: [Using this find to calibrate a molecular phylogentic tree the authors conclude "the most recent common ancestor of extant orchids lived in the Late Cretaceous (76-84 Myr ago)" p. 1042].

Orchidamasulitis schlechteri- upper Tertiary (Oligocene), Venezuela; Di Giacomo, 1985; Lorente, 1986.

Hoffmannseggella- see Gustafsson et al., 2010.

OROBANCHACEAE

Conopholis- As example of a Mexican disjunct lineage see Rodrigues et al. (2013): for discussions of the origins of the pattern see e.g., Graham (1973a, 1976a, 1999a, 2010, 2011a), Morris et al. ((2008, 2010).

Euphrasia minima complex- Gussarova et al., 2012: "The main split…dated to nearly 6 Ma ago was between one central/southern European alpine lineage (*E. minima* s. str.) and one northern amphi-Atlantic lineage (*E. wettsteinii*). The *E. wettstenii* lineage consisted of two cpDNA sublineages, both amphi-Atlantic and partly sympatric, estimated to have diverged 1.7 Ma ago. …as all Svalbard populations were distinctly divergent from each other as well as from all other populations in AFLP marker frequencies, it is unlikely that their establishment in Svalbard is caused by current climate warming or recent human activities. Their divergence is probably due to founder effects and genetic drift following independent earlier immigratons, possibly during the postglacial warm period 9500 to 4000 years ago" (p. 146).

OXALIDACEAE

Averrhoites affinis- late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada; Hoffman & Stockey, 1999.

Oxalis- "The inferred divergence times suggest an Eocene origin for the *Oxalis* crown group. The divergence times of the 7 lineages fall between the Middle Eocene and the Late Miocene. The *O. rosea* clade split from the North American/Eurasian *O.*

acetosella clade in the Middle Miocene" (p. 5).

PAPAVERACEAE

Subfamily Fumarioideae- 'The biogeographical analysis shows a subfamily that originated in East Asia at the end of the early Cretaceous…range extension during the Cretaceous-Palaeogene transition toward western North America' (Pérez-Gutiérrez et al., 2015).

Potomacapnos apeleutheron- Early Cretaceous, Potomac Group, Aptian, Dutch Gap locality, near Richmond, VA, leaves; Jud and Hickey, 2013.

PASSIFLORACEAE

Passiflora, subgenus *Decaloba*- Krosnick et al. (2013): "The molecular phylogeny supports a New World origin for *Passiflora*, with two independent radiations to the Old World" (p. 692). "Recent age estimates for the emergence of Passifloraceae s.s. range from 71-65 MYA (Davis et al. 2005; Hearn 2006) to 37 MYA (based on the age of Malesherbiaceae; Gengler-Nowak 2002), whereas *Passiflora* itself appeared ca. 40 MYA (Hearn 2006)" (p. 704).

Passifloroidesperma sogamosense- late Eocene, Esmeraldas Fm., Middle Magdalena Valley Basin, Colombia, seeds, aff. extant Subfamily Passifloroideae; Martínez, 2017.

Turnera- Thulin et al. (2012): "The existence of a trans-Atlantic disjunction in *Turnera* is therefore supported. It is most likely caused by long-distance dispersal and estimated to be not older than late Miocene" (p. 308).

PIPERACEAE- Smith et al. (2008): ["Molecular dating is used to place an age for the crown clades of *Piper* and *Peperomia* as well as ages for diversification within the

clades. Both genera have origins in the late Cretaceous, but species level diversification occurred much later in the Tertiary" p. 275].

Piper margaritae- Late Cretaceous, middle Guaduas Fm. (66-68 Ma), Cundiamarca, Colombia, leaf compressions; Martínez et al., 2015. "Estimates of age diveregence and lineage accumulation reveal that most of the extant diversity of the genus accrued during the last ~30 Myr" (p. 273).

"*Ziziphus" fibrillosus*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

PLANTAGINACEAE

Periporopollenites sp. 2 (cf. *Plantago*)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

PLATANACEAE- see Crane (1989) and Crabtree (1987) for reviews of Cretaceous platanoid leaves. Mindell et al. (2006): ["The fossil record for the family extends into the Early Cretaceous. Leaf compressions (Hickey and Doyle 1977) and inflorescences (Friis et al. 1988; Crane et al. 1993; Pedersen et al. 1994) of platanaceous affinity are known from the Albian of eastern North America. Three-dimensionally preserved inflorescences from the Late Cretaceous of Sweden (Friis et al. 1988) and North America (Friis et al. 1988; Magallón Puebla et al. 1997) have shown characters unknown in extant Platanaceae…also known in the Cretaceous to Tertiary genera *Platananthus* Manchester and *Macginicarpa* Manchester, the Paleogene genus of pistilate fructifications (Manchester 1986)… " (pp. 591-592)]. Platanaceae- Paleocene, Sentinel Butte Fm., ND, leaf types A-C, staminate inflorescences; Crane et al., 1990. Late Eocene (36 Ma), lower John Day Fm., OR, infructescence; Manchester & McIntosh, 2007.

Ambiplatanus washingtonensis- Late Cretaceous (Coniacian), Comox Fm., Eden Main locality, Vancouver Island, British Columbia, Canada, inflorescences, pollen; Mindell, Karafit, and Stuckey, 2014.

"*Celastrus*" *taurenensis*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Erlingdorfia montana- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Gynoplatananthus oysterbayensis- middle Eocene, Oyster Bay Fm., Appian Way locality, Vancouver Is., British Columbia, Canada, staminate inflorescences, associated pistillate fructifications; Mindell et al., 2006.

Grewiopsis saportana- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Leepierceia preartocarpoides- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Macginicarpa manchesteri- late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada; Hoffman & Stockey, 1999. *M. glabra*- middle Eocene (44 Ma), Clarno Fm., OR, infructescences; Manchester, 1994. *M.* sp.- late Paleocene, Almont Fl., ND, infrutescence, Pigg & DeVore, 2010 (pers. comm.. from Manchester); middle Eocene, Republic Fl., WA, fruits; Wehr & Manchester, 1996.

Macginitiea gracilis- late Paleocene, Almont, Beicegel Fls., ND, leaves, Pigg & DeVore, 2010 (pers. comm. from Manchester); late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage, Dillhoff et al., 2005; middle Eocene Republic Fl., WA, leaves, Wolfe and Wehr, 1987; Manchester, 1986.

Platanites marginata- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Platanoxylon haydenii- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002. *P.* sp. (Platanaceae?)- Late Cretaceous (Maastrichtian), McRae Fm., NM, wood; Estrada-Ruiz et al., 2012.

Platananthus speirsiae- late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada; Hoffman & Stockey, 1999.

Platanus condonii- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997. *P. dissecta*- late Miocene (Clarendonian, 12 Ma), Ironside Fm., OR, leaf; Retallack, 2004; late Miocene, Vasa Park Fl., King Co., WA, leaf, Dillhoff et al., 2014 *P. hirticarpa*- middle Eocene (44 Ma), Clarno Fm., OR, infructescences; Manchester, 1994. *P. idahoensis*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves; Axelrod, 1998a. *P. leucophylla*- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. *P. nobilis*- late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada; Hoffman & Stockey, 1999. *P. paucidentata*- middle Miocene, Mint Canyon Fl., (preliminary study), so. CA; Axelrod, 1940. *P. raynoldsii*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; earliest Paleocene, basal Fort Union Fm., ND, leaves, Bercovici et al., 2008; Paleocene, Ludlow Member, Fort Union Fm., ND, SD, megaflora, Johnson, 2002. *P. salmonense*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves; Axelrod, 1998a. *P.* sp.- middle Eocene, Claiborne Group, TN, leaves; Dilcher & Lott, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014. cf. *Platanus*- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Tanyoplatanus cranei- middle Eocene (44 Ma), Clarno Fm., OR, infructescences; Manchester, 1994.

Tricolpites hians (*Platanus*)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, pollen; Daly et al., 2011.

"*Vitis*", aff. *V. stantonii*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

cf. *Wardiaphyllum daturaefolium*- Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora; Johnson, 2002.

POACEAE (Strömberg, 2004, and personal communication, 2011). Early records from New World and outside the New World: "Presumed grass pollen (*Monoporites*) in the Maastrichtian to Paleocene [70 to 60 million years ago (Ma)] of South America, India, and North Africa marks the earliest fossil record of Poaceae [Grass Phylogeny Working Group, 2001; Jacobs et al., 1999], and unequivocal macrofossils of crown-group Poaceae appear no earlier than the Late Paleocene [Jacobs et al., 1999; Bremer, 2002]" Prasad et al., 2005, p. 1177; phytoliths, Late Cretaceous dinosaur coprolites, India, Prasad et al., 2005; 2011. pollen undifferentiated- latest Eocene (34.1 Ma), Florissant Fl., CO, Leopold & Clay-Poole, 2001; Late Miocene (Clarendonian, 12 Ma), Ironside Fm., OR, Retallack, 2004; late middle to early late Miocene, Bryn Mawr Fm., Md., Pazzaglia et al., 1997; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014. See also Christin et al., 2014- '…estimates of divergence time remain stongly affected by different implementations of fossil calibration points. Analyses calibrated with only macrofossils lead to estimates for age of core Poaceae ~51-55 Ma, but the inclusion of

microfossil evidence pushes this age to 74-82 Ma and leads to lower estimated evolutionary rates in grasses These results emphasize the importance of considering markers from multiple genomes and alternative fossil placements when addressing evolutionary issues that depend on ages estimated for important groups.'

Changii indicum- Late Cretaceous (67-65 Ma), phytoliths in coprolites from red clays, Lameta Fm., Pisdura East and Pisdura South, India; Prasad et al., 2011.

Graminidites- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Phalaris- Voshell et al. (2011): "…it appears that Mediterranean Europe is likely to be the center of origin for the genus, rendering western North America, as a secondary center of diversity and polyploidy. However, a biogeographic study is underway to evaluate this hypothesis" (p. 1314).

Phragmites sp.- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007.

Paleocene/Eocene Wilcox Fm. (specimens now regarded as from the Eocene part of the Wilcox Fm.), western TN, spikelets, inflorescence fragments with included pollen; Crepet & Feldman, 1991.

Late Eocene Chadron Fm., early Oligocene Brule Fm. (White River Group), late Oligocene-early Miocene Monroe Creek Fm., early Miocene Harrison Fm. and Anderson Ranch Fm. (Arikaree Group), early Miocene Runningwater Fm. and Box Butte Fm. (Ogallala Group), northwestern NB; phytoliths; Strömberg, 2004.

Stipa (or a similar genus of grass fruits)- latest Eocene (34.1 Ma), Florissant Fl., CO; Manchester, 2001.

Tateokai deccana- Late Cretaceous (67-65 Ma), phytoliths, septaria, concretions in clays, Lameta Fm., Dhamni, India; Prasad et al., 2011: "The new Oryzeae fossils

suggest substantial diversification within Ehrhartoideae by the Late Cretaceous, pushing back the time of origin of Paceae as a whole. These results, therefore, necessitate a re-evaluation of current models for grass evolution and palaeobiogeography" (p. 1).

Zea mays- Holocene (3940 to 2450 ^{14}C yrs BP), packrat middens, Chaco Canyon, NM; Hall, 2010.

POLYGALACEAE

Paleosecuridaca curtisii- late Paleocene, Williston Basin, Almont, Beicegel Fls., Crane et al., 1990, Pigg et al., 2008, Pigg & DeVore, 2010.

POLYGONACEAE

Polygonocarpum johnsonii- Late Cretaceous (Maastrichtian), Slope Co., ND, fruit; Manchester & O'Leary, 2010: [Family previously known from the Oligocene (Germany) and Miocene (Switzerland), "It is now possible to extend the fossil record of Polygonaceae considerably farther back in time based on fossil fruits from the Late Cretaceous and Paleocene of North America" (p. 69). "Two additional representatives of Polygonaceae are recognized from the Paleocene of North America. Fruits similar to those of *Polygonocarpum johnsonii* occur in the Paleocene of Wyoming and North Dakota" (p. 70)]. *P. curtisii*- Paleocene, ND, fruit; Manchester & O'Leary, 2010.

Polygonum- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Podopterus antiqua- Paleocene, ND, fruit; Manchester & O'Leary, 2010; considered *Ulmus* by Brown, 1962; 'biwinged fruit', Crane et al., 1990).

POTAMOGETONACEAE

Potamogeton sp.- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaf, Axelrod, 1998; latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, fruits, Manchester, 2001; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014.

PROTEACEAE- see also Bowman et al., 2014, latest Cretaceous/earliest Paleocene, Seymore Island, Antarctica; Gonzalez et al. (2007) for a review of Proteaceae macrofossils from Patagonia, Argentina: Tufolitas Laguna del Hunco (early Eocene), Chubut Province; Ventana (middle Eocene), Río Negro Province; and the Río Nirihuau (late Oligocene- early Miocene), Río Negro Province: "The authors confirm the presence of *Lomatia preferruginea, L. occidentalis, L. patagonica, Roupala patagonica,* and *Orites bivascularis*; *Embothrium precoccineum* and *E. pregrandiflorum* doubtful" (pp. 235-236).

Banksieaidites- lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005.

Beaupreadites verrucosus- mid-early Paleocene, Antarctic Peninsula, pollen; Poole et al., 2005. *B.* sp.- Late Cretaceous (late Maastrichtian), Antarctic Peninsula, pollen; Poole et al., 2005.

Cranwellia cf. *striatus*- Late Cretaceous (late Maastrichtian), Antarctic Peninsula, pollen, Poole et al., 2005.

Cranwellipollis palisadus- Late Cretaceous (late Maastrichtian), Antarctic Peninsula, pollen, Poole et al., 2005.

Gevuina avellana- last interglacial (MIS 5e- called Valdivia in southern Chile), Mancera interglacial sequence, Mancera Island, Chile, leaves; Astorga & Pino, 2011.

Granodiporites- lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005.

Lomatia dentata- last interglacial (MIS 5e- called Valdivia in southern Chile), Mancera interglacial sequence, Mancera Island, Chile, leaves; Astorga & Pino, 2011.

Peninsulapollis askinae- Late Cretaceous (late Maastrichtian), Antarctic Peninsula, pollen, Poole et al., 2005. *P. gillii, P. truswelli*- mid-early Paleocene, Antarctic Peninsula, pollen; Poole et al., 2005. *P. gillii*- Late Cretaceous (late Maastrichtian), Antractic Peninsula, pollen; Poole et al., 2005.

Propylipollis- mid-early Paleocene, Antarctic Peninsula, pollen; Poole et al., 2005. *P. rynthius*- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Proteaceae- middle Eocene, Antarctic Peninsula, pollen, leaf; mid-early Paleocene, lower middle Eocene, early-late Paleocene, Late Cretaceous (late Maastrichtian), Late Cretaceous (Coniacian to Campanian), Antarctic Peninsula, pollen, Poole et al., 2005. [Pollen of several modern genera cited as similar].

Proteacidites subscabratus- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012. *P. symphyonemoides*- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

RANUNCULACEAE- the fossil record of the family is reviewed by Pigg & DeVore (2005, pp. 1650-1651 and table 1). See also Bowman et al., 2014, latest Cretaceous/earliest Paleocene, Seymore Island, Antarctic Peninsula.

Anemone type- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005. Hoot et al., 2012: "The topology … suggest that the anemones originated in the Northern Hemisphere and subsequently spread to the Southern Hemisphere, a pattern that is shared with other members of the Ranunculaceae" (p.

139).

Echitricolpites supraechinatus (possibly Ranunculaceae)- late Paleocene, Almont Fl., ND, Williston Basin, pollen; Zetter et al., 2011.

Leefructus mirus- Lower Cretaceous (122.6-125.8 Ma),Yixian Fm., China, leaves attached to stem; Sun et al., 2011 (see also Angiospermae).

Paleoactaea nagelii- late Paleocene, Almont, Beicegel Fls., ND, fruit, seeds; Pigg & DeVore, 2005: ["This fruit bears a striking resemblance to extant *Actea*, the baneberry (Ranunculaceae)… A second species, *Paleoactaea bowerbanki*...is recognized from the early Eocene London Clay flora" (p. 1650)]; Crane et al., 1990, Pigg & DeVore, 2010.

RAPATEACEAE (see discussion under Bromeliaceae)

RESTIONACEAE

Milfordia- lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005.

Restioniidites- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

RHAMNACEAE- Correa et al. (2010): ["The Maastrichtian age of these fossils [*Berhamniphyllum, Archaeopaliurus*] predates the ages previously estimated for the Rhamneae tribe [(28.5 Ma) and the Paliureae tribe (31.6 Ma) using a modified clock approach. There are worldwide records of megafossils leaves from Rhamnaceae with the oldest report coming from the Albian-Cenomanian of the Russian Federation (Spicer et al., 2002)" (p. 71)]. The specimen recorded earlier from Salmon, Idaho, as *Ceanothus* (Brown, 1935) is considered by Axelrod (1998a, p. 56) to be *Cercidiphyllum crenatum*. See also Richardson et al, 2004.

Archaeopaliurus boyacensis- Late Cretaceous (upper Maastrichtian), Guaduas Fm. (ca.

68 Ma), Colombia, leaves; Correa et al., 2010.

Berhamniphyllum claibornense- middle Eocene, Claiborne Group, TN, leaves; Dilcher & Lott, 2005. *B.* sp.- Late Cretaceous (upper Maastrichtain), Guaduas Fm. (ca. 68 Ma), Colombia, leaves, Correa et al., 2010; middle Eocene, Claiborne Group, TN, leaves, Dilcher & Lott, 2005.

Ceanothus precuneatus, C. sp.- middle Miocene, Mint Canyon Fl. (preliminary study), so. CA; Axelrod, 1940. [see note under family].

Hovenia oregonensis- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997.

Notiantha grandensis- Paleocene (early Danian), Lower Salamanca Fm., Rancho Grande,Chubut, Argentina, flowers; Jud et al., 2017.

Paliurus clarenensis, P. favonii- genus middle Eocene to late Miocene (North America), Late Eocene to Pleistocene (Asia), Oligocene to Pliocene (Europe), fossil history based on fruits and biogeography of the genus summarized by Burge and Manchester, 2008. *P. blakei*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR; Meyer & Manchester, 1997.

Rainbowia rhamnoides- Eocene, Green River Fm., UT, fruit; Manchester & O'Leary, 2010: ["…similar to those of *Gouania* " (p. 73)].

Rhamnus columbiana- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves; Axelrod, 1998a. *R. deweyensis, R. pushoides*- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaves; Axelrod, 1998. "*Rhamnus*" *cleburni*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002. cf. "*Rhamnus" goldiana*- earliest Paleocene, basal Fort Union Fm., ND, leaves; Bercovici et al., 2008.

Suessenia grandensis- Paleocene (early Danian), Lower Salamanca Fm., Rancho Grande, Chubut, Argentina, leaves; Jud et al., 2017

RHIZOPHORIACEAE- see Kennedy et al., 2016.

RHOIPTELEACEAE

aff. *Rhoiptelea* sp.- latest Eocene (34.1 Ma), Florissant Fl., pollen; Leopold & Clay-Poole, 2001.

ROSACEAE (see also *Ozakia*, Angiospermae *incertae sedis*)

Amelanchier covea, A. grayi- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR; Meyer & Manchester, 1997. *A. deweyensis*- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaf; Axelrod, 1998. *A. dignatus*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves; Axelrod, 1998a. *A.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaves; Manchester, 2001.

Cercocarpus cuneatus- middle Miocene, Mint Canyon Fl. (preliminary study), so. CA; Axelrod, 1940. *C. myricaefolius*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaf; Axelrod 1998a. *C. ovatifolius*- late Miocene (Clarendonian, 12 Ma), Ironside Fm., OR; Retallack, 2004. *C.*-like leaves, fruits- latest Eocene (34.1 Ma), Florissant Fl., CO; Manchester, 2001.

Crataegus bakeri, C. cuspicaulis, C. haynesii, C. spathulatoides- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves, stem; Axelrod, 1998a. *C. merriamii*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997. cf. *Cratageus* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage; Dillhoff et al., 2005. *C.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, fruits; Manchester, 2001. cf. *Crataegus* sp.- Miocene (15-6 Ma), Iceland;

Grimsson & Denk, 2007.

Eleopoldia sp.- Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO, leaves; Gregory & McIntosh, 1996.

Heteromeles sp.- Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO, leaves; Gregory & McIntosh, 1996.

Holodiscus lisii- late Eocene, Florissant Fl., CO, leaves; Schorn, 1998. *H.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, Manchester, 2001; Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO, leaves, Gregory & McIntosh, 1996.

Lyonothamnus mohavensis- middle Miocene, Mint Canyon Fl. (preliminary study), so. CA; Axelrod, 1940.

Maloidoxylon annae- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Malus collardii- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaf; Axelrod, 1998. *M.*-like leaves- latest Eocene (34.1 Ma), Florissant Fl., CO; Manchester, 2001. cf. *Malus* or *Pyrus*- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen, Leopold & Clay-Poole, 2001; Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997.

Neviusia dunthornei (Tribe Kerrieae)- lower-middle Eocene, Allenby Fm., near Princeton, British Columbia, Canada; leaves; DeVore et al., 2004, other fossil rosaceous leaves are discussed by the authors, p. 199; middle Eocene, Republic Fl., WA, DeVore et al., 2004.

Oemleria janhartfordae (Subfam. Spiraeoideae, Tribe Osmaronieae)- late early Eocene, Republic Fl., WA; flowers; Benedict et al., 2011.

Photinia pagae- middle Eocene, Republic Fl., WA; Wolfe & Wehr, 1987.

Prunus cathybrownae (Subfam. Spiraeoideae, Tribe Amygdaleae)- late early Eocene, Republic Fl., WA, Benedict et al., 2011; *P. chaneyii*- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaves; Axelrod, 1998. ["The endocarps from Wutu [Shandong Province, China] represent the earliest record [early Eocene] of *Prunus* in Asia. The fossil data suggest that the genus first appeared in the early Eocene of North America and Asia, then extended to Europe in the middle Eocene" Li et al., 2011, p. 555]. cf. *Prunus gummosa, P.* sp.- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002. *P. olsonii, P. weinsteinii*- middle Eocene (44 Ma), Clarno Fm., OR, fruits; Manchester, 1994. *P.*-like leaves, latest Eocene (34.1 Ma), Florissant Fl., CO; Manchester, 2001. cf. *Prunus* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage; Dillhoff et al., 2005. cf. *Pyracantha*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997. See also Wen et al., 2008.

Pyrus (see *Malus*)

Rosa hillae- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaflet, Axelrod, 1998; Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf, Meyer & Manchester, 1997; Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaflets, Axelrod 1998a; latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, leaflets, Manchester, 2001; Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, fruit, Meyer & Manchester, 1997.

Rosaceous prickly stems- late Eocene (36 Ma), lower John Day Fm., OR, Manchester & McIntosh, 2007; Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR,

Meyer & Manchester, 1997.

Rubus ameyeri (leaf)*, R. fremdii* (leaf)*, R.* sp. (fruit)- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR; Meyer & Manchester, 1997. *R.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaves; Manchester, 2001.

Sorbus cassiana, S. mcjannetii- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaflets; Axelrod, 1998a. *S. oblongifolia*- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaflet; Axelrod, 1998.

Spiraea idahoensis- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaf, Axelrod, 1998; Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaf, Axelrod, 1998a.

Subclass Rosidae and Hamamelididae (see Hamamelididae).

Vauquelinia sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, Manchester, 2001; Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaf, Axelrod, 1998a.

RUBIACEAE [early records- *Emmenopterys* (middle Eocene, OR, WA); *Faramea* (late Eocene, Panama); *Guettarda* (as *Guettardidites*, late Eocene, Australia); *Canthium* (as *Rubipollis oblatus*, late Eocene, Australia); Graham 2009].

Dicotyloxylon pluriperforatum- middle Eocene, Antarctic Peninsula, wood; Poole et al., 2005.

Emmenopterys dilcheri- middle Eocene (44Ma), Clarno Fm., OR, infructescences and fruits; Manchester 1994. *E.* sp.- middle Eocene, Republic Fl., WA, fruit; Wehr & Manchester 1996.

Faramea- late Eocene, Gatuncillo Fm., Panama, pollen; Graham, 1985.

cf. *Paleorubiaceophyllum* sp.- middle Eocene, Claiborne Group, TN, leaves, Dilcher & Lott, 2005.

Pinckneya dilcheri- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, seed; Meyer & Manchester, 1997.

RUPPIACEAE

?*Ruppia*- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

RUTACEAE

aff. *Evodia* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

Ptelea enervosa- Miocene, Hog Creek, Succor Creek (near OR-ID border), Stinking Water (OR) Fls., samaras; Call & Dilcher, 1995. *P. miocenica*- late Miocene (Clarendonian, 12 Ma), Ironside Fm., OR; Retallack, 2004. ?*Ptelea*- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

Rhoipites baculatus (Rutaceae-?Araliaceae)- Paleogene, Ñirihuau Basin, Argentina, pollen; Quattrocchio et al., 2012.

Tricolporopollenites sp. 3+4 (cf. *Zanthoxylum*)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Zanthoxylum sp.- late Eocene (36 Ma), lower John Day Fm., OR, seeds, Manchester & McIntosh, 2007; cf. *Xanthoxylum*- late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005.

SABIACEAE (MELIOSMACEAE)

Meliosma beusekomii, M. bonesii, M. elongicarpa, M. cf. *jenkinsii, M. leptocarpa*- middle Eocene (44 Ma), Clarno Fm., OR, endocarps; Manchester, 1994. *M. brehmii, M. deweyii, M. dodosonii* (+ subgenera, wood groups I-VI)- middle Eocene (44 Ma),

Clarno Fm., OR, wood; Wheeler & Manchester, 2002. *M. rostellata*- Paleocene, Sentinel Butte Fm., Almont, Beicegel Fls., ND, fruits, Crane et al., 1990, Pigg & DeVore, 2010; late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada, Hoffman & Stockey, 1999. *M.* sp.- middle Eocene, Republic Fl., WA, fruit; Wehr & Manchester, 1996.

Sabia americana- middle Eocene (44 Ma), Clarno Fm., OR, endocarps, locule casts; Manchester, 1994. *S.* sp.- middle Eocene, Republic Fl., WA, fruits, Wehr & Manchester, 1996; late Eocene (36 Ma), lower John Day Fm., OR, endocarp, Manchester & McIntosh, 2007.

SALICACEAE

Populus sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage, Dillhoff et al., 2005; middle Eocene, Claiborne Group, TN, leaves, Dilcher & Lott, 2005; middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaves, Axelrod, 1998; latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, fruits, Manchester, 2001, pollen, Leopold & Clay-Poole, 2001; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014. *P.* sp. (ex group *P. tremula*), *P.* sp. 1-3- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. *P.* sp.- late Miocene (Clarendonian, 12 Ma), Ironside Fm., OR; Retallack, 2004. *P. nebrascensis*- earliest Paleocene, basal Fort Union Fm., ND, leaves; Bercovici et al., 2008. *P. cinnamonoides, P. eotremuloides, P.* sp.- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaf; Axelrod, 1998a. *P.* sp.- Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO, leaves; Gregory & McIntosh, 1996.

See also "*Populus*", Cercidiphyllaceae.

Salix gruberi- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. *S. lemhiensis, S.*

salmonensis, S. sp.- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves, Axelrod 1998a. *S.* sp.- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaves, Axelrod, 1998*;* latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, Manchester, 2001, pollen- Leopold & Clay-Poole, 2001; Oligocene (32.9-29 Ma), Pitch Pinnacle Fl., CO, leaves, Gregory & McIntosh, 1996; late Miocene (Clarendonian, 12 Ma), Ironside Fm., OR, Retallack, 2004; late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014.

SAPINDACEAE/SAPINDALES/SAPINDALEAN (see also Hippocastanaceae)

Acer- based on up to seven chloroplast loci "The nine North American species of *Acer* diverged from their nearest relatives at widely different times: eastern American *Acer* diverged in the Oligocene and Late Miocene; western American species in the Late Eocene and Mid Miocene; and the *Acer* core clade, including *A. saccharum*, dates to the Miocene" (Renner et al., 2008, p. 795). "The oldest described *Acer* fossils are Paleocene fruits from North America and Eurasia (Wolfe & Tanai, 1987; Crane et al., 1990; Manchester, 1999; Kittle et al., 2005), but still older fruits from the Maastrichtian (66.5 Ma) Hell Creek formation in South Dakota also conform morphologically to *Acer* (K. R. Johnson, personal communication [to Renner], August 2008). None of these ancient isolated fruits, however, can securely be assigned to an extant clade" (Renner et al., 2008, p. 798). Wolfe & Tanai, 1987.

Acer crenatifolium subsp. *islandicum, A. askelssonii*- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. *A. hueberi, A. idahoensis, A. macginitiei, A. osmonti, A.*

salmonensis, A. septilobatum, A. tiffneyi- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves, seeds; Axelrod, 1998a. *Acer ashwillii, A. cranei, A. glabroides, A. kluckingii, A. manchesteri, A. oligomedianum, A. osmontii, A.* sp. 1, 2, *A.* sp. A, B- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaves, fruits; Meyer & Manchester, 1997. *A. integrifolioxylon*- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002: ["To our knowledge, this is the oldest report of fossil wood with characteristics of the genus *Acer*" (p. 36]. *A. rousei, A. stewarti, A. wehri, A.* sp. (foliage)- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, fruits; Dillhoff et al., 2005. cf. *Acer*- late Paleocene, Almont, Beicegel Fls., ND, fruit, Crane et al., 1990, Kittle et al., 2005, Pigg & DeVore, 2010. *A*. sp.- late middle Eocene (ca. 45 Ma), Green River Fl., CO, UT, leaves, McMurran & Manchester, 2010; latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, fruits, Manchester, 2001, pollen, Leopold & Clay-Poole, 2001; middle Eocene, Republic Fl., WA, fruits, Wehr & Manchester, 1996; late Eocene (36 Ma), lower John Day Fm., OR, endocarp, Manchester & McIntosh, 2007; Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO, leaves, Gregory & McIntosh, 1996; late middle to early late Miocene, Bryn Mawr Fm., MD, pollen, Pazzaglia et al., 1997; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005; late Miocene- Vasa Park Fl., King Co., WA, leaves, seeds, pollen, Dillhoff et al., 2014.

Aesculipollis wyomingensis- Late Paleocene, Almont Fl., Williston Basin, North Dakota, pollen; Zetter et al., 2011.

Aesculus sp.- late Miocene, Vasa Park Fl., King Co., WA, leaf, Dillhoff et al., 2014.

Bohlenia americana- middle Eocene, Republic Fl., WA, fruits, Wehr & Manchester,

1996; Wolfe & Wehr, 1987.

Bridgesia bovavensis- Eocene, Bovay Clay Pit, Holly Springs, MS, fruit; Manchester & O'Leary, 2010: ["…interesting biogeographic implications because the genus is known today only in South America" (p. 76)].

Cardiospermum sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

Cupania- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

Cupanieidites orthoteichus (Sapindaceae-Cupanieae)- Late Cretaceous (late Maastrichtian), lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005.

Cupanites sp.- middle Eocene, Claiborne Group, TN, leaflet; Dilcher & Lott, 2005.

Deviacer wolfei- middle Eocene (44 Ma), Clarno Fm., OR, samara; Manchester, 1994.

D. ("*Acer*" *arcticum*) sp.- late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada, Hoffman & Stockey, 1999; middle Eocene, Republic Fl., WA, fruits, Wehr & Manchester, 1996.

Dipteronia- ["The earliest fossils of *Dipteronia* (McClain & Manchester, 2001) are from the Paleocene Fort Union Formation in central Wyoming and are 60 to 63 Myr. *Dipteronia* fruits are also well represented at Middle Eocene localities in Washington, Oregon, and British Columbia, and at Late Eocene localities in Colorado, western Montana, and Oregon (McClain & Manchester, 2001). The only locality of Oligocene age is from the Bridge Creek flora of Oregon, 32 Myr" (Renner et al., 2008. p. 797-798)]. *Dipteronia brownii*- McClain & Manchester (2001) review the fossil record of *Dipteronia* (sister genus to *Acer*), Paleocene to Oligocene, greatest number in middle to late Eocene of western North America (no known fossil occurrences outside of North

America), fruits; *D. brownii*- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage, Dillhoff et al., 2005; middle Eocene, Republic Fl., WA, [*Bohlenia* was originally proposed by Wolfe & Wehr, 1987 for fruits and leaves; McClain & Manchester, 2001 suggest fruits could all be recognized under *Dipteronia* and that *Bohlenia* should be used for just the associated leaves]. *D.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, fruits, perhaps leaves, Manchester, 2001. Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, fruit, Meyer & Manchester, 1997.

Koelreutaria sp.- middle Eocene, Republic Fl., WA, fruits, Wehr & Manchester, 1996; latest Eocene (34.1 Ma), Florissant Fl., CO, fruits, perhaps leaves, Manchester, 2001, pollen, Leopold & Clay-Poole, 2001.

Palaeoallophylus globosa, P. gordonii- middle Eocene (44 Ma), Clarno Fm., OR, seeds; Manchester, 1994.

Ptelea paliuruoides- middle Eocene, Parachute Creek Member, Green River Fm., CO, UT; Manchester & O'Leary, 2010.

Pteleaecarpum- [affinities originally suggested with Sapindaceae, now considered as tiliaceous; Kvaček et al., 1991].

Sapindoxylon klaassenii- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

cf. *Sapindus*- late Paleocene, Almont Fl., ND, fruit, Pigg & DeVore, 2010 (pers. comm. from Manchester).

Striatopollis tectatus- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011.

Incertae sedis:

Landeenia aralioides [extinct sapindalean genus]- middle Eocene, Bridger Fm., WY, flowers, pollen infructescences, fruits, seeds; Manchester & Hermsen, 2000.

[see also *Aesculus*, Hippocastanaceae; *Sapindopsis*, Subclass Hamamelididae].

SAPOTACEAE

Subfamily Chrysophylloideae- (Bartish et al., 2010): ["…earliest diversification of Chrysophylloideae was in the Campanian of Africa *c*. 73-83 Ma. A narrow time interval for colonization from Africa to the Neotropics (one to three dispersals) and Australasia (a single migration) indicates a relatively rapid radiation of this subfamily in the latest Cretaceous to the earliest Palaeocene (*c*. 62-72 Ma)", p. 1. [The authors review the fossil record of the family].

Brumelia? *globosa, B.*? *subangularis*- middle Eocene (44 Ma), Clarno Fm., OR, seeds; Manchester, 1994: [*Bumelia*? *globosa* Manchester was transferred to *Sargentodoxa globosa* (Manchester) Manchester 1999. This was moved out of Sapotaceae and into Sargentodoxaceae.

SARGENTODOXACEAE (see *Brumelia* above)

SAURURACEAE

Saururus tuckerae- middle Eocene, Allenby Fm., Princeton Group, Princeton, British Columbia, Canada, flowers, pollen; Smith & Stockey, 2007: ["To date only two fossil species are known for Saururaceae, and there are few confirmed reports of fossil Piperaceae. Fruits and seeds of *Saururus bilobatus* have been recognized from the Late Eocene to Pliocene of Europe and Siberia (Mai and Walther, 1978; Friis, 1985; Stuchlik et al., 1990; Lesiak, 1994), and seeds of *Houttuynia bavarica* (Mai, 1999) from the

Miocene of Germany. These are known from gross morphology and have not been anatomically examined. No fossil vegetative or pollen remains have been firmly placed in the family Saururaceae. However, we recently recognized that fossil flowers from the Middle Eocene Princeton Chert, previously thought to have affinities to Alismatales … have many similarities to saururaceous flowers" (p. 1642)].

SAXIFRAGALES- Soltis, D. E. et al. (+ 7 authors): "The earliest fossil evidence of Saxifragales is within the Turonian-Campanian, providing a minimum age of 89.5 Myr for the group (Magallón et al., 1999; Hermsen et al., 2006)." (p. 917, see other references in paragraph to fossil record of Saxifragales). "Again, we acknowledge the known issues of estimating extinction rates from molecular phylogenetics based upon extant taxa in the absence of a complete fossil record (Rabosky, 2009, 2010; reviewed in Quental and Marshall, 2010), and these findings warrant future investigation." (p. 925-926).

SCHISANDRACEAE

Schisandra oregonensis- middle Eocene (44 Ma), Clarno Fm., OR, seeds; Manchester, 1994.

SIMAROUBACEAE

Ailanthus confucii- Muellner et al., 2006: ["dated to be 52 million years (my) old (Early Eocene; Corbett and Manchester, 2004)", p. 241] . *S.* sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, fruits, Manchester, 2001; late middle Eocene (ca. 45 Ma), Green River Fm., CO, UT, leaves, McMurran & Manchester, 2010.

SMILACACEAE- P. Li et al., 2013: "The Upper Midwest Driftless Area previously has been identified in geological and palynological studies as an ice-free area that may have served as a northern glacial refugium for temperate deciduous forests and their biological

inhabitants…Our study of the *Smilax herbacea* complex provides the first documented example that understory herbs also may have persisted in the Driftless Area as a Midwest northern refugium disjunct from far northwestern and southern refugia in the United States during the LGM" (p. 812). [see also Soltis et al., 2006].

Smilax lehmiensis- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaf; Axelrod, 1998a. *S. magma*, late Miocene, Vasa Park Fl., King Co., WA, leaf, Dillhoff et al., 2014; *S.* sp. 1 & 2- middle Eocene, Claiborne Group, TN, leaves; Dilcher & Lott, 2005. *S.* sp. Miocene (15-6 Ma), Iceland, Grimsson & Denk, 2007.

Smilax miohavanensis- Miocene, western Eurasia (with Caribbean affinities; Havanensis group), leaves; Denk et al., 2015.

SOLANACEAE- Olmstead (2013): "Recent molecular phylogenetic studies of Solonales and Lamiales show that Solanaceae, Verbenaceae and Bignoniaceae all diversified in South America. Estimated dates for the stem lineages of all three families imply origins in the Late Cretaceous, at which time South America had separated from the united Gondwanan continent" (p. 80).

A preliminary press report by Oskin (2013; http://www.livescience.com/40935-oldest-tomatillo-fossil-south-america.html)) of Solonaceae from 52.2. Ma deposits in South America refers to *Physalis* currently under study (Wilf, pers. comm.., 2013).

Brunfelsia- Filipowicz & Renner, 2012: "Our results imply that *Brunfelsia* is 16-21 Myr old and entered the Antilles from South America early during its history, with subsequent expansion along the island arc. The only shift to hummingbird pollination occurred on Cuba, which also harbors the largest single radiation, with 11 species (10 included in our

study) that apparently arose over the past 4 Myr. Jamaica, Hispaniola, and Puerto Rico each sustained smaller radiations" (p. 1).

Datura sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

Physalis- early Eocene (52.2 Ma), Huitrera Fm., Laguna del Hunco fossil-lake beds, Chubut, Patagonia, Argentina, fruits; Wilf et al., 2015. *P. infinemundi*- op cit., Wilf et al, 2017.

Solanum morelliforme- Simon et al. (2011): Hawkes (1990) hypothesized section *Petota* to have originated in the late Cretaceous to Eocene eras in North and Central America…He also suggested that some of these species migrated during the mid-Eocene to Pliocene eras to South America. Recent molecular clock data (Wang et al. 2008) indicated that eggplant and tomato/potato shared a common ancestor approximately 14 MYA and potato and tomato seven MYA, so it seems unlikely that the timing for the events proposed by Hawkes really took place in the Cretaceous-Eocene eras… literally all sister groups of section *Petola* are confined to South America (p. 1065).

SPARGANIACEAE

Sparganium- late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005.

STAPHYLEACEAE (see Tapisciaceae)

STERCULIACEAE

Dicotyophyllum washbernii- middle Eocene, Antarctic Peninsula, leaf; Poole et al., 2005.

Florissanatia quilchenensis- middle Eocene, Republic Fl., WA, flowers, stamens; Wehr

& Manchester, 1996. *F. speirii*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, flower, fruit; Meyer & Manchester, 1997. *F.* sp.- latest Eoene (34.1 ma), Florissant Fl., CO, flowers, fruits, Manchester, 2001, pollen (*F.*- type), Leopold & Clay-Poole, 2001.

Fremontia (*Fremontodendron*; Sterculiaceae/Malvaceae) *lobata*- middle Miocene, Mint Canyon Fl. (preliminary study), so. CA; Axelrod, 1940.

Sterculia- early Eocene, Caleta Cocholgüe Fl., central Chile, leaves; Gayó et al., 2005.

STYRACACEAE

Flectorivus microdontos- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997.

Halesia sp.- Oligocene (32.9-29 Ma), Pitch-Pinnacle Fl., CO, leaves; Gregory & McIntosh, 1996.

SYMPLOCACEAE

Symplocos hitchcockii- early Miocene, Brandon Lignite Fl, VT, endocarps; Tiffney et al., 2018.

Symplocos laevigata- early Miocene, Brandon Lignite Fl. VT, endocarps; Tiffney et al., 2018.

Symplocos nooteboomii- middle Eocene (44 Ma), Clarno Fm., OR, endocarps; Manchester, 1994. *S.* sp.- late middle to early late Miocene, Bryn Mawr Fm., MD, pollen; Pazzaglia et al., 1997.

TAPISCIACEAE

Tapiscia occidentalis- middle Eocene (44 Ma), Clarno Fm., OR, fruit, seed cast; Manchester, 1994. [formerly placed in the Staphyleaceae].

TETRACENTRACEAE

Tetracentron sp.- middle Eocene, Republic Fl., WA, Pigg et al., 2007; Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007.

THEACEAE

Cleyera grotei- middle Eocene (44 Ma), Clarno Fm., OR, seed; Manchester, 1994.

cf. *Gordonia* sp.- middle Eocene, Claiborne Group, TN, flower, Dilcher & Lott, 2005; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005.

Ternstroemites sp.- middle Eocene, Claiborne Group, TN, leaves; Dilcher & Lott, 2005.

TICODENDRACEAE- Gómez-Laurito & Gómez P., 1989; Hammel & Burger, 1991; see also Incertae Sedis (angiospermae).

Ferrignocarpus bivalis (*Ticodendron*)- middle Eocene, Clarno Fm., OR, fruits; Manchester, 2011.

Ticodendron- (Graham, 2010): "Once the distinctive features [of the extant species] became known, fossil leaf and fruit collections were re-examined for specimens with these features. Both leaves and fruits of *Tiocodendron*, or with *Ticodendron* affinities, have been found in North America (*Ferrignocarpum* from the middle-late Eocene Clarno flora of Oregon; fruits about one-third the size of *Ticodendron*) and Europe (*Carpolithus* sp. 38 from the early Eocene London Clay flora of England, now *Ferrignocarpus*, see above; Steven Manchester, Susanne Renner, personal communication, 2005). Fossils of *Ticodendron* have not been found in Latin America (the pollen is similar to *Carpinus* and *Corylus* of the Betulaceae), but it, or its progenitor, apparently is another amentiferous woody genus like *Alfaroa* and

Oreomunnea that migrated from the north or differentiated in the temperate cloud forests of Mexico and Central America" (p. 176-177).

TILIACEAE- Manchester, 1994: ["The radiation of Tiliaceae…was underway by the Late Cretaceous, as indicated by fossil wood (Wheeler et al., 1987) and pollen (Muller, 1978), but the first reliable evidence of the genus *Tilia* is about 20 million years later in the Tertiary" (p. 1176)].

Craigia bronnii, C. oregonensis- Tertiary, Eurasia, North America, fruits; Kvaček et al., 1991, [affinities originally cited as with Sapindaceae; Bůžek et al., 1989]: "Tertiary fruit remains of *Pteleaecarpum*…interpreted as valves of winged capsules of an extinct sapindaceous genus, are now recognized as belonging to a living genus of Tiliaceae. The fossil fruits, which are common in the Tertiary of western North America, Europe, and Asia, are virtually identical in morphology and anatomy to fruits of *Craigia* W. W. Smith and Evans, an extant tiliaceous genus of southern China" p. 522]. *Craigia oregonensis*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, fruits, Axelrod, 1998a; Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, fruit, Meyer & Manchester, 1997. *C.* sp.- middle Eocene, Republic Fl., WA, fruit; Wehr & Manchester, 1996.

Intratriporopollenites sp. (*Tilia*)- Miocene, Tepoztlán Fm., Mexico, pollen; Lenhardt et al., 2013.

Plafkeria obliquifolia- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997.

Pteleaecarpum (see *Craigia*).

Tilia aspera- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves; Axelrod, 1998a. *T.*

circularis (type A bracts)- early Oligocene, John Day Fm., Bridge Creek Fl., Lyons Fl., OR. *T. circularis*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves; Axelrod, 1998a. *T. pedunculata* (type B bracts)- late Eocene to middle Miocene of western North America, lower Miocene to Pliocene of western and central Europe, Eagle Creek and Bridge Creek Fl., OR; Type C bracts (Asia), Manchester, 1994. *T. circularis, T. pedunculata, T. aspera, T. fossilensis, T. lamottei*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, bracts, fruits, leaves; Meyer & Manchester, 1997. *T. johnsoni*- middle Eocene, Republic Fl., WA.; Wolfe & Wehr, 1987. *T. selardalense*- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007. *T.* sp.- late middle to early late Miocene, Bryn Mawr Fm., MD, pollen; Pazzaglia et al., 1997. *T.* and types- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Tiliaephyllum tsagajanicum (*Tilia*)- late Paleocene (~60 Ma), Sagwon Bluffs, North Slope Alaska, leaf; Daly et al., 2011.

TORICELLIACEAE (see Incertae Sedis, angiospermae, *Tripartisemen bonesii*; for European fossil record see Meller, 2006).

Toricellia bonesii- middle Eocene (44 Ma), Clarno Fm., OR, seed; Manchester, 1994. [formerly *Tripartisemen bonesii*]. *T.* sp.- late Paleocene, Almont Fl., Williston Basin, ND, fruit; Zetter et al., 2011

TRAPACEAE (see Lythraceae)

cf. TRIURIDACEAE (trimerous staminate flower)- Late Cretaceous (late Santonian), Buffalo Creek Member, Gaillard Fm., Allon Fl., GA; Herendeen et al., 1999.

TRIMENIACEAE

Periporopollenites polyoratus- lower middle Eocene, Antarctic Peninsula, pollen; Poole et al., 2005.

TROCHODENDRACEAE- the fossil history of the family is discussed by Manchester et al., 1991, pp. 357-358; Pigg et al., 2001, 2007; and Crane et al., 1991: "Trochodendrales …first appear in the mid-Cretaceous (Doyle and Hickey, 1976; Hickey and Doyle, 1977; Crabtree, 1987; Upchurch and Wolfe, 1987) but are particularly common during the Paleocene" (pp. 1311-1312).

Nordenskioldia borealis- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Ludlow Member of Fort Union Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Sentiel Butte Fm., Almont, Beicegel Fls., ND, fruits, dispersed achenes, leaves, Crane et al., 1990, 1991, Pigg et al., 2001.

N. interglacialis- Miocene, Latah and associated floras (14.5-16.5 Ma), British Columbia, Canada, WA, ID, infructescences, seeds, and *Nordenskioldia* sp. infructescence and *Zizyphoides*-like leaves, Manchester et al., 1991.

Nordenskioldia/Zizyphoides- late Paleocene, Williston Basin, Almont, Beicegel Fls.; Pigg & DeVore, 2010.

Tetracentron hopkinsii- early/middle Eocene, Allenby Fm., Okanogan Highlands, McAbee, British Columbia, Canada, leaves; Pigg et al., 2007 [also report *Tetracentron* sp. from the Republic Fl., WA].

Trochodendron drachukii- early/middle Eocene, unnamed Fm. of the Kamloops Group, Okanogan Highlands, McAbee, British Columbia, Canada, infructescence, seeds, associated *Trochodendron*-like leaves; Pigg et al., 2007; *T. nastae*- middle Eocene, Klondike Mountain Fm., Republic, WA, leaves, associated infructescences, fruits; Pigg

et al., 2001. See also Wang et al., 2009. *T.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, leafy twigs, foliage, fruits, Dillhoff et al., 2005; middle Eocene, Republic Fl., WA, fruits, Wehr & Manchester, 1996.

Trochodendroides nebrascensis- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora; Johnson, 2002.

Zizyphoides auriculata- Miocene, Cook Inlet, AK, WA, Idaho; leaves; Manchester et al., 1991. *Z. flabella*- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, Megaflora, Johnson, 2002; Paleocene, Ludlow Member, Fort Union Fm., ND, SD, megaflora, Johnson, 2002; late Paleocene, Almont, Beicegel Fls., ND, leaf, Crane et al., 1990, 1991, Pigg & DeVore, 2010. *Z.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage; Dillhoff et al., 2005.

TURNERACEAE (see Passifloraceae)

TYMELIACEAE

Daphne sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

TYPHACEAE

Typha lesquereuxi- middle Eocene (45 Ma), Thunder Mountain Fl., ID, leaf; Axelrod, 1998. Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves, stems; Axelrod, 1998a.

Typha/Sparganium (pollen undifferentiated)- latest Eocene (34.1 Ma), Florissant Fl., CO; Leopold & Clay-Poole, 2001. Late Miocene, Vasa Park Fl., King Co., WA, pollen; Dillhoff et al., 2014.

ULMACEAE (see also Canabaceae)

Carpites ulminiformis- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD,

megaflora; Johnson, 2002.

Cedrelospermum lineatum- middle Eocene (44 Ma), Clarno Fm., OR, samara; Manchester, 1994. Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf, fruit; Meyer & Manchester, 1997. *C.* sp.- middle Eocene, Republic Fl., WA, fruit, Wehr & Manchester, 1996; latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, fruits, Manchester, 2001.

Chaetoptelea microphylla- late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada; Hoffman & Stockey, 1999.

Eoceltis dilcherii- middle Eocene Claiborne Fm., TN, flowers; Zavada & Crepet, 1981.

Planera type- late Miocene, Upper Beluga Fm., south coast Alaska, pollen; Reinink-Smith & Leopold, 2005.

Polyporopollenites undulosus (*Ulmus*)- Miocene, Tepoztlán Fm., Mexico, pollen, Lenhardt et al., 2013.

Pteroceltis sp.- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

Ulmipollenites tricostatus- late Paleocene, Almont Fl., Williston Basin, ND, pollen; Zetter et al., 2011.

Ulmus- Denk & Dillhoff, 2005: "The fossil record of *Ulmus* extends back to the late Early Eocene of western North America, based on leaves co-occurring with fruits (MacGinitie 1941; Burnham 1986; Manchester 1989), while leaf remains attributed to *Ulmus* or showing closest affinities to the genus have been reported from Paleocene to Eocene sediments from North America, Russia, Spitsbergen, China, and Japan" (p. 1664). *U. chuchuanus*- early-middle Eocene, British Columbia, Canada, Republic,

WA, leaves; Denk & Dillhoff, 2005. *U. danielii*- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002. *U. knowltoni*- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaf; Axlerod, 1998a. *U. okanaganensis*- early-middle Eocene, Okanagan Highlands, McAbee, British Columbia, Canada, Republic, WA, leaves, flower fasciles, fruits; Denk & Dillhoff, 2005. *U. chaneyi, U. speciosa, U.* sp. 1, 2, A, B,- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek, Fl., OR, leaves, fruits; Meyer & Manchester, 1997. *U. speciosa*- late Miocene, Vasa Park Fl., King Co., WA, leaf, Dillhoff et al., 2014; *U.* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, leafy twigs, foliage, fruit, *Ulmus/Zelkova* pollen, Dillhoff et al., 2005; early-middle Eocene, Republic, WA, fruits, Denk & Dillhoff, 2005; middle Eocene, Republic Fl., WA, fruits, Wehr & Manchester, 1996; latest Eocene (34.1 Ma), Florissant Fl., CO, leaves, fruits, Manchester, 2001, *U./Zelkova* pollen, Leopold & Clay-Poole, 2001; Oligocene (32.9-29 Ma), Pitch Pinnacle Fl., CO, leaves, Gregory & McIntosh, 1996; late middle to early late Miocene, Bryn Mawr Fm., MD, Pazzaaglia et al., 1997; late Miocene, Upper Beluga Fm., south coast Alaska, pollen, Reinink-Smith & Leopold, 2005. *U.* cf. *pyramidalis, U.* sp.- Miocene (15-6 Ma), Iceland; Grimsson & Denk, 2007; *U.* sp.- late Miocene, Vasa Park Fl., King Co., WA, pollen, Dillhoff et al., 2014.

Zelkova brownii- Oligocene (30.7 Ma), Haynes Creek Fl., ID, leaves; Axelrod, 1998a.

"*Zelkova*" *hesperia*- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, leaf; Meyer & Manchester, 1997.

VERBENACEAE (see also Solonaceae; Lamiales)

Frost, L. A. et al. 2017. Origins of North American arid-land Verbenaceae: More than one way to skin a cat. American Journalof Botany 104: 1708-1716.

"Phylogenetic inference suggests a South American origin for Verbenaceae, with approximately six colonization events having given rise to the Old World species" (Marx et al., 2010).

Lantaneae- Lu-Irving & Olmstead (2013): "Lantaneae have shifted into the Neotropics from the southern temperate subtropics and have colonized Africa in at least two seperate long-distance dispersal events' (p. 103).

VITACEAE- late Eocene (36 Ma), lower John Day Fm., OR, seeds; Manchester & McIntosh, 2007 (family assignment).

Ampelocissus auriforma, A. scottii- middle Eocene (44 Ma), Clarno Fm., OR, seeds; Manchester, 1994. *A.* sp.- late Paleocene, Almont, Beicegel Fls., ND, leaf, Pigg & DeVore, 2010 (pers. comm. from Manchester).

Ampelopsis rooseae- middle Eocene (44 Ma), Clarno Fm., OR, seed; Manchester, 1994.

cf. *Leea*- late Eocene, Tonosi flora, Pacific coast central Panama, seed; Herrera et al., 2012.

Parthenocissus angustisulcata, P. clarnensis- middle Eocene (44 Ma), Clarno Fm., OR, seeds; Manchester, 1994. *P./Cissus*- latest Eocene (34.1 Ma), Florissant Fl., CO, pollen; Leopold & Clay-Poole, 2001.

Saxuva draculoidea- late Eocene, Tonosi Fl., Pacific coast central Panama, seed; Herrera et al., 2012.

Vitaceoxylon carlquistii, V. tiffneyi- middle Eocene (44 Ma), Clarno Fm., OR, wood; Wheeler & Manchester, 2002.

Vitis margnisperma, V. tiffneyi- middle Eocene (44 Ma), Clarno Fm., OR, seeds; Manchester, 1994. cf. *Vitis* sp.- late early Eocene (49-52 Ma), McAbee Fl., British Columbia, Canada, foliage; Dillhoff et al., 2005. *V.* sp.- Oligocene (33.6-32.2 Ma), John Day Fm., Bridge Creek Fl., OR, seed; Meyer & Manchester, 1997.

VOCHYSIACEAE- Sytsma et al. (2004): "No fossils have been reported that unambiguously belong to the Heteropyxidaceae, Psiloxylaceae, or the Vochysiaceae" (p. 589). "The African lineage of Vochysiaceae is nested within a South American clade and probably arose via long-distance dispersal in the Oligocene at a time when the Atlantic had already rifted 80 m.yr. at the equatorial region" (p. 585). There are, however, several reports, at least of *Vochysia,* in the Quaternary and Tertiary of Latin America (Graham, 2010, p. 601).

ZINGIBERACEAE

Spirematospermum chandlerae- Upper Cretaceous (Santonian or Campanina), Black Creek Fm., Neuse River Cut-Off, NC, seeds; Friis, 1988: ["Recently seeds of *Spirematospermum* have been recovered from Upper Cretaceous strata in Europe (Knobloch & Mai, 1986) and North America (present study). *S. chandlera* described here from the Upper Cretaceous of North America is the first report of the genus outside Eurasia and represents the earliest known occurrence of the genus. During the Tertiary remains of *Spirematospermum wetzleri* first appear in the Upper Eocene strata of southern England, become abundant in the Upper Oligocene and Miocene strata of Europe and Siberia, and in Europe persist into the Pliocene" (p. 7). *S.* sp.- late Paleocene, Almont, Beicegel Fls., ND, embryo, seed, Crane et al., 1990; Benedict et al., 2007; Pigg & DeVore, 2010.

Zingiberopsis attenuata- Late Cretaceous (Maastrichtian), Hell Creek Fm., ND, SD, megaflora, Johnson, 2002; Paleocene, Paskapoo Fm., Alberta, Canada, leaves, Hickey & Peterson (1978); late Paleocene, Joffre Bridge Fl., Red Deer Valley, Alberta, Canada, Hoffman & Stockey, 1999.

ZYGOPHYLLACEAE

Gauiacum minuta- early middle Eocene, Aycross Fm., WY; megafossils; Leopold & MacGinitie, 1972, p. 193.

Larrea- Lia et al. (2001): "under the molecular clock hypothesis, nucleotide sequence divergence between *L. divaricata* and *L. tridentata* suggests a Late Neogene (8.4 to 4.2 mybp) time of arrival of the diploid ancestors of *L. tridentata* to North American deserts" (p. 309).

Laport, R. G et al. (2012): "These findings suggest a recent origin of the North American creosote bush via long distance dispersal, with establishment of polyploid populations accompanying its rapid spread through the Northern Hemisphere" (p. 153).

[Tentative identifications, ordinal referrals, informal citation of biological affinities]. The reliability of these identifications and referrals to extant taxa is partly a function of the age of the strata, the principal purpose of the study (stratigraphic or biological), the extent to which adequate reference collections were used in suggesting possible biological affinities, and degree of collaboration with morphologists and taxonomic specialists in extant plant groups. The biological affinity of fossil material in general, and these citations in particular, should be assessed before using them in phylogenic,

biogeographic, or paleoenvironmental reconstructions [see Graham, 2010, pp. xii-xiii, 245-246, 371].

HAMAMELIDALES *Platanophyllum groenlandicum, P. prenobile,* Early Cretaceous, Greenland, leaves; Boyd, 1998.

LAURALES. *Trilaurus sassopsis*, Early Cretaceous, Greenland, leaves; Boyd, 1998.

MYRICALES. *Myricompia groenlandica*, Early Cretaceous, Greenland, incomplete leaves; Boyd, 1998.

NYMPHAEALES. *Panefolium limnophilum*, Early Cretaceous, Greenland, leaves; Boyd, 1998.

RANUNCULALES. *Ceratophytum schornii*, *Menispermites ravnkloeftensis,* Early Cretaceous, Greenland, leaves; Boyd, 1998.

ROSALES. *Sapindopsis ravnkloeftensis*, Early Cretaceous, Greenland, incomplete stems with leaves; Boyd, 1998.

PALEOFLORAS

A number of late Cretaceous and Cenozoic floras have been described from the New World containing numerous taxa where biological affinities are cited (extant family, genus, species) or identifications made according to an artificial system (e.g., *Monoporopollenites annulatus***)** with suggested biological affinities (Poaceae). Taxa from the latter are included below if effort was made to specifically establish the biological affinities as opposed to broadly citing organisms with similar structures to illustrate a particular morphology.

Pliocene-Pleistocene, Negro River, pollen, Brazil (D'Apolito et al., 2018, table 1): *Crassoretitriletes vanraadshoovenii* (*Lygodium*), *Cyatheacidites annulatus* (*Lophosoria*),

Kuylisporites waterbolkii (*Hemitelia/Cnemidaria*), *Magnastriatites grandiosus* (*Ceratopteris*), *Podocarpus* spp., *Alnipollenites versus* (*Alnus*), *Arecipites regio* (Arecaceae), *Bombacacidites ciriloensis* (Malvaceae, Bombacoideae), *Cichoreacidites igapoensis* (*Pacourina/Vernonia*), cf. *Cichoreacidites longispinosus* (Asteraceae), *Clavainaperturites microclavatus* (*Hedyosmum*), *Clavamonocolpites lorentei* (*?Iriatea*), *Echiperiporitesakanthos* (*Sagittaria/Echinodorus*), *Echitricolporites mcneillyi* (Asteraceae), *E. spinosus* (Asteraceae), *Ericipites* cf. *annulatus* (Ericaceae), *Fenestrites spinosus* (Asteraceae), *Grimsdalea magnaclavata* (Arecaceae), *Ilexpollenites tropicalis* (*Ilex*), *Ladakhipollenites*(?) *lolongatus* (*Symmeria*), *M. alvacipolloides* aff. *maristellae* (*Abutilon*?), *Mauritiidites franciscoi* var. *fransciscoi* (*Mauritia*), *M. franciscoi* var. *minutus* (*Mauritia*), *M. franciscoi* var. *pachyexinatus* (*Mauritia*), *Monoporopollenites annulatus* (Poaceae), *Perisyncolporites pokornyi* (Malpighiaceae), *Proteacidites triangulatus* (*Allophylus*?), *Psilabrevitricolporites devriesii* (*Humiria*), *Psilatricolporites lobatus* (*Pouteria*), *Psilatricolporites operculatus* (*Alchornea*), *Psilatriporites aspidatus* (*Faramea*), *Retirescolpites*? *irregularis* (*Amanoa*), *Rhoipites manausensis* (*Schefflera*), *Stephanocolpites evansii* (*Spermacoce*).

Late Miocene Brandywine Fl., southern coastal plain, Maryland, macro- and microfossils; McCartan et al., 1990: *Isoetes, Selaginella, Pinus, Larix,Taxodium, Acer, Alangium, Alnus, Ambrosia, Artemisia, Betula, Carpinus/Ostrya, Carya, Celastrus, Ceratophyllum, Cornus, Euonymus, Fagus, Gleditsia, Hamamelis*(?), *Ilex, Juglans, Liquidambar, Liriodendron, Mneme, Nuphar, Nyssa, Parthenocissus*(?), *Platanus, Populus, Potomogeton, Prunus, Ptelea, Pterocarya, Quercus, Salix, Sambucus*(?), *Smilax, Sophora, Toxicodendron, Trapa, Typha, Ulmus, Vitis, Zelkova* type.

Late to middle Miocene, San José and Chiquimil Fms., ne Argentina, microfossils; Mautino and Anzotegui, 2014 (for fossils in Argentina with suggested affinities to Euphorbiaceae, Fabaceae, *Prosopis*, and Anacardiaceae see tables 1-4): *Ailanthipites gamerroi* (aff. Anacardiaceae, cf. *Schinus*) *Cordiapollenites espinulata* (aff. *Cordia*), *Cyperaceaepollis kyllingoides* (aff. Cyperaceae, cf. *Kyllinga*), *Euphortricolporites perforate*a (aff. *Euphorbia*), *Prosocolporites argentina* (aff. *Prosopis*).

Late Early Miocene to early Quaternary age, Arctic to Subarctic North America (Alaska, northern Canada); see review by Matthews and Overden, 1990 (tables 1-6) for location and age of the individual assemblages: *Equisetum, Selaginella selaginoides, Abies* sp., *A. grandis, Glyptostrobus, Larix groenlandii, L. minuta, L. omolica, Metasequoia disticha, Picea banksii, P, mariana, Pinus, Sciadopitys, Tsuga, Taxodium, Thuja occidentalis, Actinidia, Aldrovanda, Alnus crispa, A. incana, A. tertiaria, Alisma, Andromeda polifolia, Arctostaphylos alpine/rubra* type, *Aracites globosa, Aralia, Betula apoda, B. glaunduosa* type*, Boschniakia rossica, Brasenia schreberi, Callitriche, Caltha, Carex aquatilis, C. rostrata, Carya, Cassiope tetragona, Ceratophyllum demersum, Chamaedaphne, Chenopodium gigantospermum, Chrysosplenium, Cicuta, Claytonia, Cleome, Comptonia, Cornus stolinifera, C. canadensis, Chamaedaphne, Crataegus, Cyperus* sp., *Decodon*, *Diervilla*, *Draba, Dryas, Dullchium vespiforme, Eleocharis palustris/uniglumis* type*, Empetrum nigrum, E. crassum, Epipremnum crassum, Eriophorum, Eriophyllum, Fragaria, Glyceria, Hedysarum, Hippuris, Hypericum, Juglans eocineria, Ledum, Liriodendron, Lonicera, Ludwigia, Lycopus, Melandrium, Menyanthes trifoliata, Microdiptera/Mneme* type, *Morus, Myrica eogale, Myriophyllum spicatum/exalbescens* type*, Nuphar, Nymphaea,Nymphoides, Oxycoccus, Oxyria digyna,*

Paliurus, Papaver, Parnassia, Phyllanthus, Physocarpus, Polanisia, Polygonum amphiblum, Populus, Potamogeton alpinus, P. epihydrus, P. filiformis, P. pectinatus, P. richardsonii, P. spirillus, Potentilla palustris, P. norvegica, Primula, Prunus maximoviczii, Potentilla palustris, P. anserina, P. norvegica, Ranunculus hyperboreus, R. macounii/pensylvanicus type, *R. lapponicus*, *R. sceleratus, trichophyllus* type, *Rhynchospora capitelliata, Roippa islandica, Rosa, Rubus articus, R. ideaus, R. idaeus, Rumex arcticus, Sagisma, Sagittaria, Salix, Sambucus, Saxifraga oppositifolia, Scheuchzeria, Scirpus microcarpus, S. validus, Sedum, Sesuvium, Silene, Solanum/Physalis* type, *Sorbus, Sparganium hyperboreum, Stelleria, Symphoricarpus, Teucrium, Thalictrum, Triglochin maritimum, Vaccinium vitis-idaea, Verbena, Viola, Vitis, Wiegela*.

Middle Miocene floras (15 Ma, 13.5 Ma; Selárdalur-Botn, Dufansdalur-Ketilseyri Fms.), macrofossils, Iceland, Grímsson et al., 2007, tables 1,2: *Glyptostrobus europaeus, Picea*, *Sequoia abietina, Aesculus, Betula, Cerdidiphyllum, Fagus friedrichii, Magnolia, Platanus leucophylla, Tilia selandalense, Ulmus.*

Middle Miocene (Barstovian, 16.3-13.6 Ma), Fort Preston Fm., Liberty County, Florida, macrofossils (leaves, leaflets, fruits, seeds), Lott et al., 2019: cf. *Adiantum, Carex, Carya* cf. *serraefolia,* cf. *Paliurus, P. favonii, Platanus,* cf. *Salix, S. varians, Sambucus, Scirpus, Ulmus prestonia.*

Late Eocene, Florissant Fm., Colorado, microfossils; Bouchal et al., 2016; as noted, included are only identifications to biological genus or to families (e.g., Poaceae, Ericaceae) where this is the usual level of identication: *Abies, Cathaya, Ephedra, Ginkgo, Larix, Pseudotsuga, Picea, Pinus, Tsuga, Acer, Alnus, Asteraceae, Betula,*

Carya, Celtis, Cercocarpus/Purshia, Chenopodiaceae, Crataegus, Diosperus, Ericaceae, Eucommia, Fraxinus, Juglans, Momipites (*Engelhardia*) *coryloides, M. microfoveolatus, M. triradiatus*, Onagraceae (aff. *Hauya*), *Platanus, Poaceae, Quercus, Sarcobatus, .Sparganium, Tetracentron, Typha, Ulmus.*

For a historical review of paleobotanical studies of the early Eocene floras of the Okanagan (Okanogan) Highlands of British Colombia and Washington state see Greenwood et al., 2016.

Eocene, Collins Glacier Fl., wood specimens probably weathered from the Middle Unit of the Fildes Fm., Fildes Peninsula, King George Island, Antarctica; Poole et al., 2001: *Cupressinoxylon* sp. (Cupressaceae), *Podocarpoxylon fildesense* (Podocarpaceae), *Myceugenelloxylon antarcticus* (Myrtaceae), *Nothofagus corrugatus*, *N. neuquense, N. scalariforme,* (Nothofagaceae), *Weinmannioxylon eucryphiodes* (Cunoniaceae).

In the late Paleocene Late Sagwon Fl. from the Prince Creek Fm., Sagavanirktok River, no. Alaska Peninsula fossil leaves are described but without reference to extant genera/families (other floras are mentioned); Moiseeva et al., 2009: *Archeampelos mulllii, Dichotylophyllum sagwonicum, Tiliaephyllum brookense.*

Late Paleoclene-early Eocene Thyra Ø Fl./Fm., eastern northern Greenland, leaves; Boyd, 1990: *Dennstaedtia* cf. *blomstrandia, Equisetum, Cephalotaxus, Ginkgo* cf. *adiantoides, Metasequoia* cf. *occidentalis, Elatocladus, Cercidiphyllum* cf. *cuneatum,* cf. *Corylus jelissejevii, Musophyllum groenlandicum* (Heliconiaceae, Mussaceae, Strelitziaceae), *Platanus*.

Paleocene-Eocene (Danian to Ypresian), Chicxulub impact crater, cores of the International Ocean Discovery Program (IODP) Expedition 365, microfossils, Smith et

al., 2019. This first paper (Part 1) deals with spores and gymnosperm pollen and only broad biological affinities are noted: *Ceratosporites* (probably Selaginellaceae), *Deltoidospora* (Polypodiaceae, Pteridaceae; possibly *Acrostichum, Antrophyum*), *Echinatisporis* (Selaginellaceae, possibly *Selaginella*), *Foveotriletes crater* (probably *Cnemidaria*; possibly Lycopodiaceae), *Gleicheniidites senonicus* (Gleicheniaceae), *Hamulatisporis hamulatis* (Lycopodiaceae, possibly *Lycopodium*), *Kuylisporites waterbolkii* (*Cnemidaria, Cyathea*), *Neoraistrickia* (probably Selaginellaceae, *Selaginella*), *Raistrickia* (probably Selaginellaceae), *Retitriletes* (probably Lycopodiaceae), *Undulatisporites elsikii, U. mineri* (probably Polypodiaceae, possibly Ophioglossaceae), *Microfoveolatosporites* cf. *M. fromensis* (Schizaeaceae), *Cycadopites follicularis* (Cycadaceae), *Ephedripites* (*Distachyapites*) *eocenipites* (Ephedraceae, probably *Ephedra*), *Gnetaceapolllenites* (Ephedraceae, possibly *Ephedra*).

Late Paleocene, Cross Valley Fm., Seymour Island, Antarctica, leaves; Tosolini et al., 2013. The flora was initially described by Dusén (1908) and the angiosperm taxa revised here by Tosolini et al, 2013. Among those with biological affinities considered most well-established are Atherospermataceae, *Caldcluvia mirabilis* (Cunoniaceae), Myracaceae (possibly *Myrica*), *Nothofagus*, Proteaceae, and Winteraceae (*Drimys*).

Early Paleocene through the middle Eocene, Eureka Sound Group- Expedition, Strand Bay, Iceberg, and Buchanan Lake Fms., Ellesmere and Axel Heiberg Islands, macrofossils; McIver and Basinger, 1999 (appendices 1-8): cf. *Cryptogramma, Equisetum, Gleichenia, Lycopodium, Osmunda, Abies, Chamaecyparis, Glyptostrobus, Keteleeria, Larix altoborealis, Metasequoia*, *Picea, Pinus, Pseudolarix, Sequoia, Taiwania, Taxodium, Thuja polaris, Tsuga, Acer, Alnus,* cf. *Amelanchites, Archaempelos*

acerifolla, Betula, cf. *Carya*, *Castanea, Cercidiphyllum, Corylus, Diervilla, Engelhardia,* Ericaceae, *Fagus*, *Fraxinus,* cf. *Grewia, Ilex, Juglans*, *Liquidambar, Lonicera, Momipites wyomingensis* (Juglandaceae), *Myrica,* cf. *Nelumbo, Nordenskioldia borealis, Nyssa, Nyssidium arcticum, Pachysandra,* cf. *Planera, Platanus,* cf. *Prunus, Pterocarya, Quercus, Rhus, Salix,* cf. *Smilax, Sparganium, Tilia, Trapago,* cf. *Trema,* cf. *Trigonobalanus, Trochodendroides*, *Ulmus,* cf. *Viburnum,* cf. *Vitis*.

Late Cretaceous (Albian-Cenomanian) Fl., Kukpowruk, Corwin Fms., Kukpowruk River, western North Slope, Alaska, macrofossils; Spicer and Herman, 2001: *Arctopteris* aff. *kolymensis, A. rarinervis*, *Birisia alata, B. ochotica, B.* cf. *oerstedtaii, Coniopteris, Equisetites, Gleichenia, Onychiopteris* cf. *psilotoides, Sphenopteris* (cf. *Coniopteris saportana*); cycadophytes- *Ctenis, Heilungia* cf. *oloensis, Nilsonia* cf. *decursiva. N. magnifolia, N. mennerii, N. serotina, Pseudocycas* cf. *P.* cf. *unjiga, Taeniopteris*(?); Ginkgoaleans- *Ginkgo* ex gr. *Adiantoides, G.* ex gr. *Concinna, Sphenobaiera* ex gr, *czekanowskiana, S.* ex gr. *longifolia, S.*ex gr. *biloba*; Czekanowskialeans- *Phoenicopsis* ex gr. *angustifolia;* conifers- *Cephalotaxopsis intermedia, Podozamites* ex gr. *eichwaldii, Pagiophyllum triangulare,Pityophyllum* ex gr. *nordenskioldii, P.* ex gr. *staratschinii, Pityostrobus* cf. *piceoides, Parataxodim* cf. *wigginsii;* angiosperms- *Platanus louravetlanica, Schefferaphyllum venustum*.

Late Cretaceous, upper Campanian (76.5->722.5 Ma), Jose Creek Member, McRae Fm., southcentral New Mexico, woods; Estrada-Ruiz et al., 2018: *Laurioxylon rennerae (*Lauraceae), *Macroxylon waddellii* (several families of Malpighiales, Myrtales, Oxalidales), *Tuneroxylon newmexicoeense* (cf. Dilleniaceae).

Cretaceous/Tertiary Fls., Greenland, macrofossils; Pedersen, 1976: Kome Fl., Fm.- *Cladophlebis*, *Hausmannia, Gleichenites, Laccopteris, Sphenopteris*; *Otozamites, Pterophyllum, Ptilophyllum,Taeniopteris*; *Baiera, Ginkgoites; Cyparissidum, Dammarites, Elatocladus, Pagiophyllum, Pityophyllum,, Sciadopitytes*; Atane and Pautut Fl.- *Equisetites, Gleichenites, Laccopteris, Hausmannia, Sphenopteris, Cladophlebis; Pseudocycas, Pterophyllum, Williamsonia, Pseudoctenis; Baiera. Ginkgoites; Dammarites, Pagiophyllum, Cupressionocladus, Moriconia, Sequoites, Elatocladus, Sciadopitytes, Cyparissidium; Macclintockia, Quercus, Artocarpus, Magnoliaephyllum, Menispermites, Laurophylum, Myrtophyllum, Cinnamomoides, Platanus, Platanophyllum, Dalbergites, Bauchinites, Sapindopsis, Dictylophyllum;* Tertiary Fls. (Upper Atanikerdluk, Agatdal Fms., numerous '–phyllum' types- *Cladophlevis groenlandica, Hemitelites, Ginkgo adianotoides, Metasequoia occidentalis, Cercidophyllum arcticum, Platanus, Macclintockia, Nordenskiöldia, Credneria spectabilis, Rosenkrantzia*; Ifsorisok Fm.-. *Ginkgo adiantoides, Metasequoia occidentalis, Cercidiphyllum arcticum, Platanus* cf. *P. aceroides, Credneria spectabilis.*

Late Cretaceous , La Colonia Fm., Patagonia, Argentina, aquatic plants, Cúneo et al., 2014: *Azolla* type, *Dicksonia* type, *Gleicheniidites senonicus*, *Lugiomarsiglia aquatica, Mirasolita irupensis, Malaspora lobata, Paleozolla patagonica, Regnellidium thomas-taylorii; Lygistepollenites, Microchacrydites, Podocarpidites; Arecipites, Nelumbo puerte, Pandaniidites, Peninsulapollis, Sparganiaceapollenites, Typha*-type leaves, various algae.

Middle Cretaceous, Canadian High Arctic, Hassel, Hoodoo Dome, Ellef Ringnes Island, and reputed Hassel Fms.,Sverdrup Basin, Eclipse Trough, palynological records;

Galloway et al., 2012 (table 2); morphotaxa, aff. cited only to major plant groups (Angiospermatophyta, Pinophyta, Gnetophyta, Cycadophyta, Pteridophyta).

Earlly Cretaceous (conference paper), Parque Nacional del Huascarán, Cordillera Blanca, localidad de Recuay (Formación Chimú), Peru, leaves; Benites-Palomino and Tejhada-Medina, 2014: *Brachyphyllum* (Coniferales) asociados a Williamsonáceas (*Ptilophyllum*).

REFERENCES

Alcantara, S. and L. G. Lohmann. 2010. Evolution of floral morphology and pollination system in Bignonieae (Bignoniaceae). American Journal of Botany 97: 1-15.

Amstelveen, A. L. E. 1971. A palynostratigraphical correlation of seven test wells in the coastal plain of Surinam. Geologie en Mijnbouw 21: 177-182.

Andrews, H. N., Jr. 1970. Index of generic names of fossil plants, 1820-1965. U. S. Geological Survey Bulletin 1300: 1-354.

Angiosperm Phylogeny Group. 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants. APG III. Botanical Journal of the Linnaean Society 161: 105-121.

-----. 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants. APG IV. Botanical Journal of the Linnean Society 181: 1-20.

Antonelli, A. and I. Sanmartín. 2011. Mass extinction, gradual cooling, or rapid radiation? Reconstructing the spaciotemporal evolution of the ancient angiosperm genus *Hedyosmum* (Chloranthaceae) using emperican and simulated approaches. Systematic Biology 60: 596-615.

Archangelsky, S. 2009. Biogeographic implications of Albian *Mohria*-like spores (family Anemiaceae) in SW Gondwana (Patagonia). Review of Palaeobotany and Palynology 157: 301-308.

----- and A. Archangelsky. 2006. Putative Early Cretaceous pteridaceous spores from the offshore Austral Basin in Patagonia, Argentina. Cretaceous Research 27: 473-486.

----- and -----. 2010. Revision taxonómica y estratigráfica de esporas cicatricosas del

Cretácico Inferior de Patagonia. 2. Géneros *Cicatricosisporites* Potonié & Gelletich y *Ruffordiaspora* Dettmann & Clifford. Revista Museo Argentino Ciencias Naturales, n.s., 12: 179-201.

-----, -----, and G. Cladera. 2012. Palinología y paleoambientes en el perfil de Bajo Comisión (Cretácico), provincia de Santa Cruz, Argentina. Revista Museo Argentino Ciencias Naturales. n.s., 14: 23-39.

----- and G. M. Del Fueyo. 2010. Endemism of Early Cretaceous conifers in western Gondwana. In: C. T. Gee (ed.), Plants in Mesozoic Time: Morphological Innovations, Phylogeny, Ecosystems, pp. 247-268. Indiana University Press, Bloomington.

-----, L. Lezama, and A. Archangelsky. 2000. Bibliographía Paleobotánica Argentina. Publicación Especial MEF (Museo Paleontológico Egidio Fergulio) No. 1. Trelew-Patagonia, Argentina. [Initial number in the series is by Carlos Menéndez, 1957].

----- and T. N. Taylor. 1993. The ultrastructure of in situ *Clavatipollenites* pollen from the early Cretaceous of Patagonia. American Journal of Botany 80: 879-885.

Artabe, A. E., A. B. Zamuner, and D. M. Stevenson. 2004. Two new petrified cycad stems, *Brunoa* gen. nov. and *Worsdellia* gen. nov., from the Cretaceous of Patagonia (Bajo de Santa Rosa, Río Negro Province), Argentina. Botanical Review 70: 121-133.

Askin, R. A. 1989. Endemism and heterochroneity in the Late Cretaceous (Campanian) to Paleocene palynofloras of Seymore Island, Antarctica: Implications for origins, dispersal and palaeoclimates of southern floras. Geological Society, London, Special Publications, 47: 107-119.

Astorga, G. & M. Pino. 2011. Fossil leaves from the last interglacial in central-southern

Chile: Inferences regarding the vegetation and paleoclimate. Geologica Acta 9: 45-54.

Atkinson, B. A., R. A. Stockey, and G. W. Rothwell. 2018. Tracking the initial diversification of asterids: anatomically preserved cornalean fruits from the early Coniacian (late Cretaceous) of western North America. International Journal of Plant Sciences 179: 21-35.

Axelrod, D. I. 1939. A Miocene flora from the western border of the Mojave Desert. Carnegie Institution of Washington, Publication 476. Washington, D.C.

-----. 1940. The Mint Canyon flora of southern California: A preliminary statement. American Journal of Science 238: 577-585.

-----. 1985. Miocene floras from the Middlegate Basin, west-central Nevada. University of California Publications Geological Sciences 129: 1-279.

-----. 1991. The early Miocene Buffalo Canyon flora of western Nevada. University of California Publications Geological Sciences 135: 1-76.

-----. 1996. Diverse upland Eocene forests, western U.S.A. Palaeobotanist 45: 81-97.

-----. 1998. The Eocene Thunder Mountain Flora of central Idaho. University of California Publications Geological Sciences 142: 1-61.

-----. 1998a. The Oligocene Haynes Creek Flora of eastern Idaho. University of California Publications Geological Sciences 143: 1-99.

Bailey, I. W. 1924. The problem of identifying the wood of Cretaceous and later dicotyledons: *Paraphyllanthoxylon arizonense.* Annals of Botany 34: 439-451.

Baker, P. A. et al. (+ 8 authors). 2014. The emerging field of *geogenomics*: constraining geological problems with genetic data. Earth Science Reviews 135: 38-47.

Baker, W. J. and T. L. P. Couvreur. 2013. Global biogeography and diversification of

palms sheds light on the evolution of tropical lineages. I. Historical biogeography. II. Diversification history and origin of regional assemblages. Journal of Biogeography 40: 274-285; 286-298.

Banks, H. P., A. Ortiz-Sotomayor, and C. M. Hartman. 1981. *Pinus escalantensis* sp. nov., a new permineralized cone from the Oligocene of British Columbia. Botanical Gazette 142: 286-293.

Barberi, M., M. L. Salgado-Labouriau, and K. Suguio. 2000. Paleovegetation and paleoclimate of "Vereda de Águas Emendadas", central Brazil. Journal of South American Earth Sciences 13: 241-254.

Bardon, L., J. Chamagne, K. G. Dexter, C. A. Sothers, G. T. Prance, and J. Chave. 2013. Origin and evolution of Chrysobalanaceae: Insights into the evolution of plants in the Neotropics. Botanical Journal of the Linnean Society 171: 19-37.

Baresch, A., J. A. C. Smith, K. Winter, A. L. Valerio, and C. Jaramillo. 2011. *Karatophyllum bromelioides* L.D. Gómez revisited: A probable fossil CAM bromeliad. American Journal of Botany 98: 1-4.

Barnard-Kubow, K. B., C. L. Debban, and L. F. Galloway. 2015. Multiple glacial refugia lead to genetic structuring and the potential for reproductive isolation in a herbacrous plant. American Journal of Botany 102: 1842-1853.

Barreda, V. D. and M. A. Caccavari. 1992. Mimosoideae (Leguminosae) occurrences in the early Miocene of Patagonia (Argentina). Palaeogeography, Palaeoclimatology, Palaeoecology 94: 243-252.

----- and L. Palazzesi. 2014. Response of plant diversity to Miocene forcing events: the case of Patagonia. In: W. D. Stevens, O. M. Montiel, and P. H. Raven (eds.).

Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th year. Missouri Botanical Garden Press, St. Louis. Pp. 1-25.

-----, L. Palazzesi, M. C. Tellería, L. Katinas, J. V. Crisci, K. Bremer, M. G. Passalia, R. Corsolini, R. Rodríguez Brizuela, and F. Bechis. 2010a. Eocene Patagonia fossils of the daisy family. Science 329: 1621.

-----, -----, -----, -----, and -----. 2010b. Fossil pollen indicates an explosive radiation of basal Asteracean lineages and allied families during Oligocene and Miocene times in the Southern Hemisphere. Review of Palaeobotany and Palynology 160: 102-110.

-----, -----, -----, E. B. Oliveero, J. I. Raine, and F. Forest. 2015. Early evolution of the angiosperm clade Asteraceae in the Cretaceous of Antarctica. Proceedings of the National Academy of Sciences USA 112: 10989-10994.

-----, L. Palazzesi, L. Katinas, J. V. Crisci, M. C. Tellería, K. Bremer, M. G. Passala, F. Barres, L. et al. (+ 6 authors). 2013. Reconstructing the evolution and biogeographic history of Tribe Cardueae (Compositae). American Journal of Botany 100: 867-882.

Bartish, I. V., A. Antonelli, J. E. Richardson, and U. Swenson. 2010. Vicariance or long-distance dispersal: Historical biogeography of the pantropical subfamily Chrysophylloideae (Sapotaceae). Journal of Biogeography 38: 177-190.

Bartlett, A. S. and E. S. Barghoorn. 1973. Phytogeographic history of the Isthmus of Panama during the past 12,000 years (a history of vegetation, climate, and sea-level change). In: A. Graham (ed.), Vegetation and Vegetational History of Northern Latin America, pp. 203-299. Elsevier, Amsterdam.

Batten, D. J. 1989. Systematic relationships between Normapolles pollen and the Hamamelidae. In: P. R. Crane and S. Blackmore (eds.), Evolution, Systematics, and

Fossil History of the Hamamelidae. Vol. 2. 'Higher' Hamamelidae, pp. 9-21. The Systematics Association Special Volume No. 40B. Clarendon Press, Oxford.

Becerra, J. X., K. Noge, S. Olivier, and D. L. Venable. 2012. The monophylly of *Bursera* and its impact for divergence times of Burseraceae. Taxon 61: 333-343.

Bechis, and R. Corsolini. 2012. An extinct Eocene taxon of the daisy family (Asteraceae): Evolutionary, ecological and biogeographical implications. Annals of Botany 109: 127-134.

Becker, H. F. 1959. A new species of *Mahonia* from the Oligocene Ruby flora of southwestern Montana. Contributions from the Museum of Paleontology, University of Michigan, XV: 33-38.

-----1961. Oligocene plants from the upper Ruby Basin, southwestern Montana. Geological Society of America Memoir 82: 1-127.

-----1962. Two species of *Mahonia* from the Grant-Horse Prairie Basin in southwestern Montana. Bulletin of the Torrey Botanical Club 89: 114-117.

Beilstein, M. A., N. S. Nagalingum, M. D. Clements, S. R. Manchester, and S. Mathews. 2010. Dated molecular phylogenies indicate a Miocene origin for *Arabidopsis thaliana*. Proceedings of the National Academy of Sciences USA 107: 18724-18728.

Bell, W. A. 1949. Uppermost Cretaceous and Paleocene floras of western Alberta. Geological Survey of Canada Bulletin 13: 1-231.

-----. 1956. Lower Cretaceous floras of western Canada. Geological Survey of Canada Memoir 285: 1-153.

Benedict, J. C., M. I. DeVore, and K. B. Pigg. 2011. *Prunus* and *Oemleria* (Rosaceae) flowers from the late early Eocene Republic flora of northwestern Washington state,

U.S.A. International Journal of Plant Sciences 172: 948-958.

-----K. B. Pigg, and M. L. DeVore. 2008. *Hamawilsonia boglei* gen. et sp. nov. (Hamamelidaceae) from the late Paleocene Almont flora of central North Dakota. International Journal of Plant Sciences 169: 687-700.

-----, W. Taylor, K. B. Pigg, and M. L. DeVore. 2007. Late Paleocene seeds from Beicegel Creek (McKenzie County, North Dakota, USA) with affinities to the genus *Spirematospermum* Chandler (Zingiberales). Abstract, Botany and Plant Biology 2007 (Chicago, July 2007).

Benites-Palomino, A. M. and L. Tejada-Medina. 2014. El registro de un bosque tropical en los altos Andes: evidencias de formations boscosas durante el Cretácico inferior en la Cordillera Blanca. XXIII Reunión Científica ICBAR 2014.

Bercovici, A., J. Wood, and D. Pearson. 2008. Detailed palaeontologic and taphonomic techniques to reconstruct an earliest Paleocene fossil flora: An example from southwestern North Dakota, USA. Review of Palaeobotany and Palynology 151: 136-146.

Berry, E. W. 1916. The lower Eocene floras of southeastern North America. U. S. Geological Survey Professional Paper 91: 1-481.

-----. 1930. Revision of the lower Eocene Wilcox flora of the southeastern United States. U. S. Geological Survey Professional Paper 156: 1-196.

-----. 1939. A Miocene flora from the gorge of the Yumurí River, Matanzas, Cuba. Johns Hopkins University Studies in Geology 13: 95-136.

Berry, P. E., W. J. Hahn, K. J. Sytsma, J. C. Hall, and A. Mast. 2004. Phylogenetic relationships and biogeography of *Fuchsia* (Onagraceae) based on noncoding nuclear

and chloroplast DNA data. American Journal of Botany 91: 601-614.

Biffin, E., E. J. Lucas, L. A. Craven, I. R. Costa, M. G. Harrington, and M. D. Crisp. 2010. Evolution of exceptional species richness among lineages of fleshy-fruited Myrtaceae. Annals of Botany 106: 79-93.

Blazer, A. M. 1975. Index of generic names of fossil plants, 1966-1973. U. S. Geological Survey Bulletin 1396: 1-54.

Bonnefille, R. A., A. Vincens, and G. Buchet. 1987. Palynology, stratigraphy and paleoenvironment of a Pliocene hominid site (2.9-3.3 M.Y.) at Haldar, Ethiopia. Palaeogeography, Palaeoclimatology, Palaeoecology 60: 249-281.

Boonchai, N. and S. R. Manchester. 2012. Systematic affinities of early Eocene petrified woods from Big Sandy Reservoir, southwestern Wyoming. International Journal of Plant Sciences 173: 209-227.

Borsch, T. and P. S. Soltis. 2008. Nymphales—The first globally diverse clade? Taxon 57: 1051. [Nymphales Symposium, 2008, Taxon 57: 1051-1158].

Bouchal, J. M., R. Zetter, and T. Denk. 2016. Pollen and spores of the uppermost Eocene Florissant Formation, Colorado: a combined light and scanning electron microscopy study. Grana 55: 179-245.

Boulter, M. C., W. G. Chaloner, and P. I. Holms. 1991. The IOP plant fossil record: Are fossil plants a special case? In: D. L. Hawksworth (ed.), Improving the stability of names: Needs and options, pp. 231-242. Regnum Vegetabile No. 123, Koeltz Scientific Books, Königstein, Germany.

Bowman, V. C., J. E. Francis, R. A. Askin, J. B. Riding, and G. T. Swindles. 2014. Latest Cretaceous-earliest Paleocene vegetation and climate change at the high southern

latitudes: palynological evidence from Seymore Island, Antarctic Peninsula. Palaeogeography, Palaeoclimatology, Palaeoecology 408: 26-47.

Boyd, A. 1990. The Thyra Ø Flora: toward an understanding of the climate and vegetation during the early Tertiary in the High Arctic. Review of Palaeobotany and Palynology 62: 189-203.

-----. 1992. *Musopsis* n. gen.: A banana-like leaf genus from the Early Tertiary of eastern north Greenland. American Journal of Botany 79: 1359-1367.

-----. 1998. Cuticular and impressional angiosperm leaf remains from the Early Cretaceous of West Greenland. Palaeotographica, Abt. B, 247: 1-53.

Brea, M., S. D. Matheos, M. S. Raigemborn, A. Iglesias, A. F. Zucol, and M. Prámparo. 2010. Paleoecology and paleoenvironments of podocarp trees in the Ameghino Petrified Forest (Golfo San Jorge Basin, Patagonia, Argentina): Constraints for early Paleogene paleoclimate. Geologica Acta 9: 13-28.

Bremer, K. 2002. Gondwana evolution of the grass alliance of families (Poales). Evolution 56: 1374-1387.

Brenner, G. J. 1968. Middle Cretaceous spores and pollen from northeastern Peru. Pollen et Spores 10: 341-383.

Brink, K. S., R. A. Stockey, G. Beard, and W. C. Wehr. 2009. *Cunninghamia hornbyensis* sp. nov.: Permineralized twigs and leaves from the Upper Cretaceous of Hornby Island, British Columbia, Canada. Review of Palaeobotany and Palynology 155: 89-98.

Brown, R. W. 1935. Miocene leaves, fruits, and seeds from Idaho, Oregon, and Washington. Journal of Paleontology 9: 572-587.

-----. 1939. Fossil leaves, fruits and seeds of *Cercidiphyllum*. Journal of Paleontology 13: 485-499.

-----. 1962. Paleocene floras of the Rocky Mountains and Great Plains. U. S. Geological Survey Professional Paper 375: 1-119.

Buchner, R. and M. Weber. 2000. PalDat- a palynological database: Descriptions, illustrations, identification, and information retrieval, http://www/paldat.org/).

Budantsev, L. Yu. 1982. *Alnus* Mill, species identified from leaves. In: A. Takhtajan (ed.), Magnoliophyta Fossilia URSS, 2, Ulmaceae-Betulaceae, pp. 120-128. Nauka, Leningrad. [In Russian].

Burge, D. O. & S. R. Manchester, 2008. Fruit morphology, fossil history, and biogeography of *Paliurus* (Rhamnaceae). International Journal of Plant Sciences 169: 1066-1085.

Burnham, R. J. 1986. Foliar morphological analysis of the Ulmoideae (Ulmaceae) from the Early Tertiary of western North America. Palaeontographica, Abt. B, 201: 135-167.

----- and N. L. Carranco. 2004. Miocene winged fruits of *Loxopterygium* (Anacardiaceae) from the Ecuadorian Andes. American Journal of Botany 91: 1767-1773.

Bůžek, C., Z. Kvaček, and S. R. Manchester. 1989. Sapindaceous affinities of the *Pteleacarpum* fruits from the Tertiary of Eurasia and North America. Botanical Gazette 150: 477-489.

Caccavari, M. A. and L. M. Anzótegui. 1987. Polen de Mimosoideae (Leguminosae) de la Formación Ituzaingó Plioceno superior de Corrientes Argentina. IV Congreso Latinoamericano de Paleontologia, Santa Cruz, Bolivia 1: 443-458.

----- and V. Barreda. 2000. A new calymmate mimosoid polyad from the Miocene of Argentina. Review of Palaeobotany and Palynology 109: 197-203.

Cahoon, E. J. 1972. *Paraphyllanthoxylon alabamense*, a new species of fossil dicotyledonous wood. American Journal of Botany 59: 5-11.

Call, V. B. and D. L. Dilcher. 1995. Fossil *Ptelea* samaras (Rutaceae) in North America. American Journal of Botany 82: 1069-1073.

----- and -----. 1997. The fossil record of *Eucommia* (Eucommiaceae) in North America. American Journal of Botany 84: 798-814.

Calvillo-Canadell, L., S. R. S. Cevallos-Ferriz, and L. Rico-Arce. 2010. Miocene *Hymenaea* flowers preserved in amber from Simojovel de Allende, Chiapas, Mexico. Review of Palaeobotany and Palynology 160: 126-134.

-----, -----, and M. Souse-Sánchez. 2014. A new leaf in the genus *Inga* (Fabaceae) in Eocene sediments of the La Carroza Formation, La Popa, Neuvo León, Mexico with comments on its biogeographic implications. In: W. D. Stevens, O. M. Montiel, and P. H. Raven (eds.), Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th Year. Missouri Botanical Garden Press, St. Louis. Pp. 27-39.

Cantrill, D. J. and G. J. Nichols. 1996. Taxonomy and palaeoecology of Early Cretaceous (late Albian) angiosperm leaves from Alexander Island, Antarctica. Review of Palaeobotany and Palynology 92: 1-28.

----- and I. Poole. 2005. Taxonomic turnover and abundance in Cretaceous to Tertiary wood floras of Antarctica: Implications for changes in forest ecology. Palaeogeography, Palaeoclimatology, Palaeoecology 215: 205-219.

----- and -----. 2012. The vegetation of Antarctica during geologic time. Cambridge

University Press, Cambridge.

Carpenter, R. J., A. Iglesian, and P. Wilf. 2918. Early Cenozoic vegetation in Patagonia: New insights from organically preserved plant fossils (Ligorio Márquez Formation, Argentina). International Journal of Plant Sciences 179: 115-135.

Carrizo, M. A., G. M. Del Fueyo, and S. Archangelsky. 2011. Morfología y anatomía de un helecho creciendo bajo condiciones de estrés en el aptiano de Santa Cruz, Argentina. Ameghiniana 48: 605-617.

Carvallho, M. R., F. A. Herrera, C. A. Jaramillo, S. L. Wing, and R. Callejas. 2011. Paleocene Malvaceae from northern South America and their biogeographical implications. American Journal of Botany 98: 1337-1355.

Carvalho, M. R. et al. (+ 5 authors). 2013. First record of *Todea* (Osmundaceae) in South America, from the early Eocene paleorainforests of Laguna del Hunco (Patagonia, Argentina). American Journal of Botany 100: 1831-1848.

Cevallos-Ferriz, S. R. S. and R. A. Stockey. 1988. Permineralized fruits and seeds from the Princeton Chert (middle Eocene) of British Columbia: Lythraceae. Canadian Journal of Botany 66: 303-312.

Chanderbali, A. S., H. van der Werff, and S. S. Renner. 2001. Phylogeny and historical biogeography of Lauraceae: Evidence from the chloroplast and nuclear genomes. Annals of the Missouri Botanical Garden 88: 104-134.

Chandler, M. E. J. 1963. The Lower Tertiary Floras of Southern England. III. The Bournemouth Beds: The Boscombe and Highcliffe Sands. British Museum of Natural History, London.

-----. 1964. The Lower Tertiary Floras of Southern England. IV. A Summary and

Survey of Findings in the Light of Recent Botanical Observations. British Museum of Natural History, London.

Chaney, R. W. 1944. Pliocene Floras of California and Oregon. Carnegie Institution of Washington, Publication 553. Washington, D.C.

----- and D. I. Axelrod. 1959. Miocene floras of the Columbia Plateau. Part 2. Systematic Considerations. Carnegie Institution of Washington Publication 617. Washington, D.C.

----- and E. L. Sanborn. 1933. The Goshen Flora of West Central Oregon. Carnegie Institution of Washington, Washington, D.C.

Chen, I., S. R. Manchester, and Z. Chen. 2004. Anatomically preserved seeds of *Nuphar* (Nymphaeaceae) from the early Eocene of Wutu, Shandong Province, China. American Journal of Botany 91: 1265-1272.

Chesters, K. I. M. 1957. The Miocene flora of Rusinga Island, Lake Victoria, Kenya. Palaeontographica, Abt. B, 101: 30-71.

Chmura, C. A. 1973. Upper Cretaceous (Campanian-Maastrichtain) angiosperm pollen from the western San Joaquin Valley, California, U.S.A. Palaeontographica, Abt. B, 141: 89-171.

Christin, P.-A., et al., 2014. Molecular dating, evolutionary rates, and the age of the grasses. Systematic Botany 63: 153-165.

Coiffard, C., B. A. R. Mohr, and M. E. C. Bernardes-de-Oliveira. 2013. The Early Cretaceous aroid, *Spixiarum kipea* gen et sp. nov., and implications on early dispersal and ecology of basal monocots. Taxon 62: 997-1008.

Collinson, M. E. 1983. Fossil Plants of the London Clay. The Palaeontological

Association, London.

-----. 2001. Cainozoic ferns and their distribution. Brittonia 53: 173-235.

----- and M. Pingen. 1992. Seeds of the Melastomataceae from the Miocene of central Europe. In: J. Kovar-Eder (ed.), Paleovegetational Development in Europe, pp. 129-139. Museum of Natural History, Vienna.

Corbett, S. L. and S. R. Manchester. 2004. Phytogeography and fossil history of *Ailanthus* (Simaroubaceae). International Journal of Plant Sciences 165: 671-690.

Correa, E., C. Jaramillo, S. Manchester, and M. Gutierrez. 2010. A fruit and leaves of Rhamnaceous affinities from the Late Cretaceous (Maastrichtian) of Colombia. American Journal of Botany 97: 71-79.

Couvreur, T. L. P., F. Forest, and W. J. Baker. 2011. Origin and global diversification patterns of tropical rain forests: Inferences from a complete genus-level phylogeny of palms. BMC Biology 9: 44 (http://www/biomedcentral.com/1741-7007/9/44).

Crabtree, D. R. 1987. Angiosperms of the northern Rocky Mountains: Albian to Campanian (Cretaceous) megafossil floras. Annals of the Missouri Botanical Garden 74: 707-747.

----- and C. N. Miller, Jr. 1989. *Pityostrobus makahensis*, a new species of silicified pinaceous seed cone from the middle Tertiary of Washington. American Journal of Botany 76: 176-184.

Crane, P. R. 1989. Paleobotanical evidence on the early radiation of nonmagnoliid dicotyledons. Plant Systematics and Evolution 162: 165-191.

----- and S. Blackmore (eds.). 1989. Evolution, Systematics, and Fossil History of the Hamamelididae. Vol. 2. 'Higher' Hamamelidae. Special Volume No. 40B, The

Systematics Association. Clarendon Press, Oxford.

----- and D. L. Dilcher. 1984. *Lesqueria*: An early angiosperm fruiting axis from the mid-Cretaceous. Annals of the Missouri Botanical Garden 71: 384-402.

-----, E. M. Friis, and K. R. Pedersen. 1994. Palaeobotanical evidence on the early radiation of magnoliid angiosperms. Plant Systematics and Evolution, Supplementum 8: 51-72.

----- and S. R. Manchester. 1982. An extinct juglandaceous fruit from the upper Paleocene of southern England. Botanical Journal of the Linnean Society 85: 89-101.

-----. -----, and D. L. Dilcher. 1990. A preliminary survey of fossil leaves and well-preserved reproductive structures from the Sentinel Butte Formation (Paleocene) near Almont, North Dakota. Fieldiana Geology, new series, 20: 1-63.

-----, -----, and -----. 1991. Reproductive and vegetative structure of *Nordenskioldia* (Trochodendraceae), a vesseless dicotyledon from the Early Tertiary of the Northern Hemisphere. American Journal of Botany 78: 1311-1334.

-----, K. R. Pedersen, E. M. Friis, and A. N. Drinnan. 1993. Early Cretaceous (early to middle Albian) platanoid inflorescences associated with *Sapindopsis* leaves from the Potomac Group of eastern North America. Systematic Botany 18: 328-344.

----- and R. A. Stockey. 1985. Growth and reproductive biology of *Joffrea speirsii* gen. et sp. nov., a *Cercidiphyllum*-like plant from the late Paleocene of Alberta, Canada. Canadian Journal of Botany 63: 340-364.

----- and -----. 1986. Morphology and development of pistillate inflorescences in extant and fossil Cercidiphyllaceae. Annals of the Missouri Botanical Garden 73: 382-393.

----- and -----. 1987. *Betula* leaves and reproductive structures from the middle Eocene

of British Columbia, Canada. Canadian Journal of Botany 65: 2490-2500.

----- and G. R. Upchurch, Jr. 1987. *Drewria potomacensis* gen. et sp. nov., an Early Cretaceous member of Gnatales from the Potomac Group of Virginia. American Journal of Botany 74: 1722-1736.

Crepet, W. L. 1981. The status of certain families of the Amentiferae during the middle Eocene and some hypotheses regarding the evolution of wind pollination in dicotyledonous angiosperms. In: K. J. Niklas (ed.), Paleobotany, Paleoecology, and Evolution, pp. 103-128. Praeger, New York.

-----. 1989. History and implications of the early North American fossil record of Fagaceae. In: P. R. Crane and S. Blackmore (eds.), Evolution, Systematics, and Fossil History of the Hamamelida, Vol. 2: 'Higher' Hamamelidae, pp. 45-66. Clarendon Press, Oxford.

----- and C. P. Daghlian. 1980. Castenoid inflorescences from the middle Eocene of Tennessee and the diagnostic value of pollen (at the subfamily level) in the Fagaceae. American Journal of Botany 67: 739-757.

----- and -----. 1981. Lower Eocene and Paleocene Gentianaceae: Floral and palynological evidence. Science 214: 75-77.

----- and -----. 1982. Euphorbioid inflorescences from the middle Eocene Claiborne Formation. American Journal of Botany 69: 258-266.

----- and -----. 1989. Extinct transitional Fagaceae from the Oligocene and their phylogenetic implications. American Journal of Botany 76: 1493-1505.

-----, -----, and M. Zavada. 1980. Investigations of angiosperms from the Eocene of North America: A new juglandaceous catkin. Review of Palaeobotany and Palynology

30: 361-370.

----- and D. L. Dilcher. 1977. Investigations of angiosperms from the Eocene of North America: A mimosoid inflorescence. American Journal of Botany 64: 714-725.

-----, -----, and F. W. Potter. 1975. Investigations of angiosperms from the Eocene of North America: A catkin with juglandaceous affinities. American Journal of Botany 62: 813-823.

----- and G. D. Feldman. 1991. The earliest remains of grasses in the fossil record. American Journal of Botany 78: 1010-1014.

----- and P. S. Herendeen. 1992. Papilionoid flowers from the early Eocene of southeastern North America. In: P. S. Herendeen and D. L. Dilcher (eds.), Advances in Legume Systematics: 4. The Fossil Record, pp. 43-55. Royal Botanic Gardens, Kew.

----- and K. C. Nixon. 1989. Earliest megafossil evidence of Fagaceae: Phylogenetic and biogeographic implications. American Journal of Botany 76: 842-855.

----- and -----. 1994. Flowers of Turonian *Magnoliidae* and their implications. Plant Systematics and Evolution (Supplement) 8: 73-91.

----- and -----. 1998. Fossil Clusiaceae from the Late Cretaceous (Turonian) of New Jersey and implications regarding the history of bee pollination. American Journal of Botany 85: 1122-1133.

-----, -----, and C. P. Daghlian. 2013. Fossil Ericales from the Upper Cretaceous of New Jersey. International Journal of Plant Sciences 174: 572-584. [Special Issue, Thomas N. Taylor Diamond Jubilee, Conceptual Advances in Fossil Plant Biology].

-----, -----, E. M. Friis, and J. V. Freudenstein. 1992. Oldest fossil flowers of hamamelidaceous affinity, from the Late Cretaceous of New Jersey. Proceedings of the

National Academy of Sciences USA 89: 8986-8989.

----- and D. W. Taylor. 1985. The diversification of the Leguminosae: First fossil evidence of the Mimosoideae and Papilionoideae. Science 228: 1087-1089.

----- and -----. 1986. Primitive mimosoid flowers from the Paleocene-Eocene and their systematic and evolutionary implications. American Journal of Botany 73: 548-563.

Crowl, A. A. et al. 2016. A global perspective on Campanulaceae: biogeographic, genomic, and floral evolution. American Journal of Botany 103: 233-245.

Cunéo, R. and M. A. Gandolfo. 2005. Angiosperm leaves from the Kachaike Formation, Lower Cretaceous of Patagonia, Argentina. Review of Palaeobotany and Palynology 136: 29-47.

-----, E. J. Hermsen, and M. A. Gandolfo. 2013. *Regnellidium* (Salviniales, Marsileaceae) macrofossils and associated spores from the Late Cretaceous of South America. International Journal of Plant Sciences 174: 340-349. [Special Issue, Thomas N. Taylor Diamond Jubilee, Conceptual Advances in Fossil Plant Biology].

-----, -----, M. C. Zamaloa, and E. Hermsen. 2014. Late Cretaceous aquatic plant world in Patagonia, Argentia. Plos One 9(8): e104749.doi:10.1371/journal.pone.0104749.

Daghlian, C. P. and W. L. Crepet. 1983. Oak catkins, leaves and fruits from the Oligocene Catahoula Formation and their evolutionary significance. American Journal of Botany 70: 639-649.

-----, -----, and T. Delevoryas. 1980. Investigations of Tertiary angiosperms: A new flora incuding *Eomimosoideae plumosa* from the Oligocene of eastern Texas. American Journal of Botany 67: 309-320.

Daly, R. J., D. W. Jolley, and R. A. Spicer. 2011. The role of angiosperms in Palaeocene

Arctic ecosystems: A palynological study from the Alaskan North Slope. Palaeogeography, Palaeoclimatology, Palaeoecology 309: 374-382.

D'Apolito, C., A. Silva-Caminha, C. Jaramillo, R. Dino, and E. Soares. 2018. The Pliocene-Pleistocene palynology of the Negro River, Brazil. Palynology, doi: 10.1080/0196122.2018.1437090.

Da Silva, M. J., L. Paganucci de Queiroz, A. M. Goulart de Azevedo Tozzi, G. P. Lewis, and A. Pereira de Sousa. 2012. Phylogeny and biogeography of *Lonchocarpus* sensu lato and its allies in the tribe Millettieae (Leguminosae, Papilionoideae). Taxon 61: 93-108.

Davis, C. C., C. O. Webb, K. J. Wurdack, C. A. Jaramillo, and M. J. Donoghue. 2005. Explosive radiation of Malpighiales supports a mid-Cretaceous origin of modern tropical rain forests. American Naturalist 165: E36-E65.

Del Fueyo, G. M. and S. Archangelsky. 2005. A new araucarian pollen cone with in situ *Cyclusphaera* Elsik from the Aptian of Patagonia, Argentina. Cretaceous Research 26: 757-768.

-----, -----, and A. Archangelsky. 2012. An ultrastructural study of the araucarian pollen grain *Cyclusphaera radiata* Archangelsky from the Albian of Patagonia. Review of Palaeobotany and Palynology, doi: 10.1016/j.palbo.2011.12.010.

-----, L. Villar de Seoane, A. Archangelsky, V. Guler, M. Llorens, S. Archangelsky, J. Gamerro, E. Musacchio, M. Passalia, and V. Barreda. 2007. Biodiversidad de las paleofloras de Patagonia Austral durante Cretácico Inferior. Ameghinian, 50th Anaversiario Publicación Especial, 11: 101-122.

De Lima, M. R. and M. Salard-Cheboldaeff. 1981. Palynologie des basins de Gandarela

et Fonseca (Eocene de l'etat de Minas Gerais, Bresil). Boletim IG, Instituto de Geosciencias USP 12: 33-54.

Denk, T. and R. M. Dillhoff. 2005. *Ulmus* leaves and fruits from the early-middle Eocene of northwestern North America: Systematics and implications for character evolution withn Ulmaceae. Canadian Journal of Botany 83: 1663-1681.

-----., F. Grímsson, R. Zetter, and L. A. Símonarson. 2011. Late Cainozoic Floras of Iceland, 15 million years of vegetation and climate history in the northern North Atlantic. Springer, NY.

-----, R. S. Hill, M. C. Simeone, C. Cannon, M. Dettmann, and P. S. Manos. 2019 (in press). Comment on "Eocene Fagaceae from Patagonia and Gondwana legacy in Asian rainforests". Science 364.

-----, D. Velitzelos, H. T. Güner, and L. Ferrufino-Acosta. 2015. *Smilax* (Smilacaceae) from the Miocene of western Eurasia with Caribbean biogeographic affinities. American Journal of Botany 102: 423-438.

Dettmann, M. E., D. T. Pocknall, E. J. Romero, and M. del C. Zamaloa. 1990. *Nothofagidites* Erdtman ex Potonié 1960: A catalogue of species with notes on the palaeogeographic distribution of *Nothofagus* Bl. (southern beech). New Zealand Geological Survey Palaeontological Bulletin 60: 1-79.

DeVore, M. L., P. Kendrick, K. B. Pigg, and R. A. Ketcham. 2005. CT-Scanning the London Clay: An excellent noninvasive technique for studying pyritized fossil fruits. Abstract, Botany 2005 (Austin, TX): 122.

-----, S. M. Moore, K. B. Pigg, and W. C. Wehr. 2004. Fossil *Neviusia* leaves (Rosaceae: Kerrieae) from the lower-middle Eocene of southern British Columbia.

Rhodora 106: 197-209.

----- and K. B. Pigg. 2010. Floristic composition and comparison of middle Eocene to late Eocene and Oligocene floras in North America. Bulletin of Geosciences 85: 111-134.

-----, -----, D. L. Dilcher, and D. Freile. 2014. *Catahoules grahamii*, a new genus and species of fagaceous involucres from the Oligocene Catahoula Formation, East Texas, and the middle Eocene Claiborne Formation of Kentucky and Tennessee, U.S.A. In: W. D. Stevens, O. M. Montiel, and P. H. Raven (eds.), Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th year. Missouri Botanical Garden Press, St. Louis. Pp. 40-50.

Dick, C. W., K. Abdul-Salim, and E. Bermingham. 2003. Molecular systematic analysis reveals cryptic Tertiary diversification of a widespread tropical rain forest tree. American Naturalist 162: 691-703.

Di Giacomo, E. de. 1985. *Orchidamasulitis schlechteri* nov. gen. et sp.—fósil de orchídea (masula) de edad Oligoceno encontrada en Venezuela. Proceedings VI Congreso Geologico Venezuela 1: 530-535.

Dilcher, D. L. 1963. Cuticular analysis of Eocene leaves of *Ocotea obtusifolia.* American Journal of Botany 50: 1-8.

----- 1969. *Podocarpus* from the Eocene of North America. Science: 164: 299-301.

-----, M. E. Bernardes-De-Oliveira, D. Pons, and T. Lott. 2005. Welwitschiaceae from the Lower Cretaceous of northeastern Brazil. American Journal of Botany 92: 1294-1310.

----- and P. R. Crane. 1984. *Archaeanthus*: An early angiosperm from the Cenomanian

of the Western Interior of North America. Annals of the Missouri Botanical Garden 71: 351-383.

----- and C. P. Daghlian. 1977. Investigations of angiosperms from the Eocene of southeastern North America: *Philodendron* leaf remains. American Journal of Botany 64: 526-534.

----- and G. E. Dolph. 1970. Fossil leaves of *Dendropanax* from Eocene sediments of southeastern North America. American Journal of Botany 57: 153-160.

-----, P. S. Herendeen, and F. Hueber. 1992. Fossil *Acacia* flowers with attached anther glands from Dominican Republic amber. In: P. S. Herendeen and D. L. Dilcher (eds.), Advances in Legume Systematics: 4. The Fossil Record, pp. 33-42. Royal Botanic Gardens, Kew.

----- and T. A. Lott. 2005. A middle Eocene fossil plant assemblage (Powers Clay Pit) from western Tennessee. Florida Museum of Natural History Bulletin No. 45: 1-43.

-----, -----, M. A. Gibson, and C. Dudley. 2014. An extinct caesalpinoid flower from the Eocene of western Tennessee. In: W. D. Stevens, O. M. Montiel, and P. H. Raven (eds.), Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th Year. Missouri Botanical Garden Press, St. Louis. Pp. 51-63.

----- and S. R. Manchester. 1988. Investigations of angiosperms from the Eocene of North America: A fruit belonging to the Euphorbiaceae. Tertiary Research 9: 45-58.

Dillhoff, R. M., T. A. Dillhoff, A. P. Jijina, and C. A. Strömberg. 2014. The Vasa Park Flora, King County, Washington, U.S.A.: a window into the late Miocene of the Pacific Northwest. In: W. D. Stevens, O. M. Montiel, and P. H. Raven (eds.), Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th Year. Missouri Botanical

Garden Press, St. Louis. Pp. 64-97.

Dillhoff, R. M., E. B. Leopold, and S. R. Manchester. 2005. The McAbee flora of British Columbia and its relation to the early-middle Eocene Okanagan Highlands flora of the Pacific Northwest. Canadian Journal of Earth Sciences 42: 151-166.

Dolianiti, E. 1949. Contribuiçao a flora Pliocenica de Fonseca, Minas Gerais. Anais de Academia Brasileira de Ciencias 21: 239-244.

Dorf, E. 1942. Upper Cretaceous floras of the Rocky Mountain Region. II. Flora of the Lance Formation at its type locality, Niobrara County, Wyoming. Carnegie Institution of Washington Contributions to Paleontology 508: 79-159.

Doria, G., C. A. Jaramillo, and F. Herrera. 2008. Menispermaceae from the Cerrejón Formation, middle to late Paleocene, Colombia. American Journal of Botany 95: 954-973.

Dorofeev, P. I. 1960. On the Tertiary flora of Belorussia. Botanichesky Zhurnal 45: 1418-1434.

-----. 1963. The Tertiary Floras of Western Siberia. Izdatelstvo Akademii Nauka SSSR. Moskva-Leningrad.

-----. 1988. Miocene floras of the Tambov District, Akademii Nauka SSSR. Moskva-Leningrad.

Doweld, A. B. 2017. (2548) Proposal to conserve the name *Palmoxylon* against *Fasciculites* and *Perfossus* (fossil *Arecales).* Taxon 66: 989-991.

Doyle, J. A. and L. J. Hickey. 1976. Pollen and leaves from the mid-Cretaceous Potomac Group and their bearing on early angiosperm evolution. In: C. B. Beck (ed.), Origin and Early Evolution of Angiosperms, pp. 139-206. Columbia University Press,

New York.

----- and C. L. Hotton. 1991. Diversification of early angiosperm pollen in a cladistic context. In: S. Blackmore and S. H. Barnes (eds.), Pollen and Spores, pp. 169-195. Clarendon Press, Oxford.

Drew, B. T. and K. J. Sytsma. 2011. Testing the monophyly and placement of *Lepechinia* in the Tribe Mentheae (Lamiaceae). Systematic Botany 36: 1038-1049.

----- and -----. 2012. Phylogenetics, biogeography, and staminal evolution in the tribe Mentheae (Lamiaceae). American Journal of Botany 99: 933-953.

----- and -----. 2013. The South American radiation of *Lepechinia* (Lamiaceae): Phylogenetics, divergence times and evolution of dioecy. Botanical Journal of the Linnean Society 171: 171-190.

Drinnan, A. N., P. R. Crane, E. M. Friis, and K. R. Pedersen. 1990. Lauraceous flowers from the Potomac Group (mid-Cretaceous) of eastern North America. Botanical Gazette 151: 370-384.

Dusén, P. 1908. Über die Tertiare flora der Seymour Insel. In: O. Nordenskjöld (ed.), Wissenchhafiliche Ergebnisse der Schwedischen Süpolar-Expedition 1901-1903. Geologie und Palàontologie. Norstedt & Söner, Stockholm. Pp. 1-27.

Dyjor, S., Z. Kvaček, M. Lanucka-Srodoniowa, W. Pyszynski, A. Sadowska, and E. Zasrawniak. 1992. The younger Tertiary deposits in the Gozdnica region (SW Poland) in the light of recent palaeobotanical research. Polish Botanical Studies 3: 1-129.

Eckert, A. J. and B. D. Hall. 2006. Phylogeny, historical biogeography, and patterns of diversification for *Pinus* (Pinaceae): Phylogenetic tests of fossil-based hypotheses. Molecular Phylogenetics and Evolution 40: 166-182.

Economist. 2014. Aquatic alfalfa. Economist, June 21, p. 78. [Describes Kathleen Pryer's research on the genome of *Azolla*].

Eiserhardt, W. L., J.-C. Pintaud, C. Asmussen-Lange, W. J. Hahn, R. Bernal, H. Baslev, and F. Borchsenius. 2011. Phylogeny and divergence times of Bactridinae (Arecaceae, Palmae) based on plastid and nuclear DNA sequences. Taxon 60: 485-498.

Eklund, H. 2000. Lauraceous flowers from the Late Cretaceous of North Carolina, U.S.A. Botanical Journal of the Linnean Society 132: 397-428.

----- and J. Kvaček. 1998. Lauraceous inflorescences and flowers from the Cenomanian of Bohemia (Czech Republic, central Europe). Interrnational Journal of Plant Sciences 159: 668-686.

Elliott, L. L., R. A. Mindell, and R. A. Stockey. 2006. *Beardia vancouverensis* gen. et sp. nov. (Juglandaceae): Permineralized fruits from the Eocene of British Columbia. American Journal of Botany 93: 557-565.

Elsik, W. C. 1974. *Nothofagus* in North America. Pollen et Spores 16: 285-299.

Erkens, R. H. J., L. W. Chatrou, J. W. Maas, T. van der Niet, and V. Savolainen. 2007. A rapid diversification of rainforest trees (*Guatteria*; Annonaceae) following dispersal from Central into South America. Molecular Phylogenetics and Evolution 44: 399-411.

Erwin, D. M. and H. E. Schorn. 2005. Revision of the conifers from the Eocene Thunder Mountain flora, Idaho, U.S.A. Review of Palaeobotany and Palynology 137: 125-145.

Escapa, I. H. and S. A. Catalano. 2013. Phyloenetic analaysis of Araucariaceae: Integrating molecules, morphology, and fossils. International Journal of Plant Sciences 174: 1153-2013.

Estrada-Ruiz, E., L. Calvillo-Canadell, and S. R. S. Cevallos-Ferriz. 2009. Upper

Cretaceous aquatic plants from northern Mexico. Aquatic Botany 90: 282-288.

-----, H. I. Martínez-Cabrera, and S. R. S. Cevallos-Ferriz. 2007. Fossil woods from the late Campanian-early Maastrichtian Olmos Formation, Coahuila, Mexico. Review of Palaeobotany and Palynology 145: 123-133.

-----, E., G. R. Upchurch, Jr., E. A. Wheeler, and G. H. Mack. 2012. Late Cretaceous angiosperm woods from the Crevasse Canyon and McRae formations, south-central New Mexico, USA: Part 1. International Journal of Plant Sciences 173: 412-428.

-----, G. R. Upchurch, Jr., J. A. Wolfe, and S. R. S. Cevallos-Ferriz. 2011. Comparative morphology of fossil and extant leaves of Nelumbonaceae, including a new genus from the Late Cretaceous of western North America. Systematic Botany 36: 337-351.

-----, E. A. Wheeler, G. R. Upchurch, and G. H. Mack. 2018. Late Cretaceous angiosperm woods from the McRae Formation, south-central New Mexico, USA: Part 2. International Journal of Plant Sciences 179: 136-150.

Eyde, R. H. 1988. Comprehending *Cornus*: Puzzles and progress in the systematics of dogwoods. Botanical Review 54: 1-233.

Fairon-Demaret, M. 1994 (1996). Les fruits et grains du Miocene de Bioul (Entre-Samre-et-Meuse, Belgique). Etude qualitative, quantitative et considerations paleoecologiques. Anales de la Societé Geologique Belgique 117: 277-309.

Falcon-Lang, H. J. and D. J. Cantrill. 2001. Leaf phylogeny of some mid-Cretaceous polar forests, Alexander Island, Antarctica. Geological Magazine 138: 39-52.

----- and -----. 2001. Gymnosperm woods from the Cretaceous (mid-Aptian) Cerro Negro Formation, Byers Peninsula, Livingston Island, Antarctica: the arborescent vegetation of a volcanic arc. Cretaceous Research 22: 277-2293.

-----, V. Mages, and M. Collinson. 2016. The oldest *Pinus* and its preservation by fire. Geology 44: 303-306.

Falder, A. B., R. A. Stockey, and G. W. Rothwell. 1999. In situ fossil seedlings of a *Metasequoia*-like taxodiaceous conifer from Paleocene river floodplain deposits of central Alberta, Canada. American Journal of Botany 86: 900-902.

Fanton, J., F. Ricardi-Branco, D. Dilcher, and M. Bernardes-de-Oliveira. 2006. *Iara Iguassu*, a new taxon of aquatic angiosperm from the Crato palaeoflora (Lower Cretaceous, Santana Formation, Araripe Basin, northeastern Brazil). Geociências (UNESP, Sâo Paulo) 25: 211-216.

Filipowicz, N. and S. Renner. 2012. *Brunfelsia* (Solanaceae): A genus evenly divided between South America and radiations on Cuba and other Antillean islands. Molecular Phylogenetics and Evolution 64: 1-11.

Fishbein, M., D. Chuba, C. Ellison, R. J. Mason-Gamer, and S. P. Lynch. 2011. Phylogenetic relationships of *Asclepias* (Apocynaceae) inferred from non-coding Chloroplast DNA sequences. Systematic Botany 36: 1008-1023.

Fontaine, W. M. 1889. The Potomac or Younger Mesozoic Flora. U. S. Geological Survey Monograph 15. Washington, D.C.

Forest, F., V. Savolainen, M. W. Chase, R. Lupia, A. Bruneau, and P. R. Crane. 2005. Teasing apart molecular-versus fossil-based error estimates when dating phylogenetic trees: A case study in the birch family (Betulaceae). Systematic Botany 30: 118-133.

Fournier, G. R. 1982. Palynostratigraphic analysis of cores from site 493, Deep Sea Drilling Project Leg 66. Initial Reports of the Deep Sea Drilling Project 66: 661-670.

Franck, A. R., B. J. Cochrane, and J. R. Garey. 2013. Phylogeny, biogeography, and

infrageneric classification of *Harrisia* (Cactaceae). Systematic Botany 38: 210-223.

Frederiksen, N. O. 1985. Review of Early Tertiary sporomorph ecology. American Association of Stratigraphic Palynologists Contribution Series 15: 1-55.

Friis, E. M. 1985. Angiosperm fruits and seeds from the middle Miocene of Jutland (Denmark). Det Kongelife Danske Videnskaberne Selskab Biologiske Skrifter 24: 1-165.

-----. 1988. *Spirematospermum chandlerae* sp. nov., an extinct species of Zingiberaceae in the North American Cretaceous. Tertiary Research 9: 7-12.

-----, P. R. Crane, and K. R. Pedersen. 1988. Reproductive structures of Cretaceous Platanaceae. Biologiske Skrifter 31: 1-55.

-----, K. R. Pedersen, and P. R. Crane. 1991. *Esqueiria* gen. nov., fossil flowers with combretaceous features from the Late Cretaceous of Portugal. Biologiske Skrifter 41: 1-45.

-----, -----, and -----. 2000. Fossil floral structures of a basal angiosperm with monocolpate, reticulate-acolumellate pollen from the Early Cretaceous of Portugal. Grana 39: 226-239.

-----, -----, -----. 2006. Cretaceous angiosperm flowers: Innovation and evolution in plant reproduction. Palaeogeography, Palaeoclimatology, Palaeoecology 232: 251-293.

-----, -----, -----. 2014. Welwitschioid diversity in the Early Cretaceous: evidence from fossil seeds with pollen from Portugal and eastern North America. Grana 53: 175-196.

Frumin, S., H. Eklund, and E. M. Friis. 2004. *Mauldinia hirsuta* sp. nov., a new member of the extinct genus *Mauldinia* (Lauraceae) from the Late Cretaceous (Cenomanian-

Turonian) of Kazakhstan. International Journal of Plant Sciences 165: 883-895.

Funk, V. A., C. Kelloff, and R. Chan. 2012. Phylogeny and biogeography of the tribe Liabeae (Compositae subfamily Cichorioideae). Taxon 61: 437-455.

Gabel, M. L. 1987. A fossil *Lithospermum* (Boraginaceae) from the Tertiary of South Dakota. American Journal of Botany 74: 1690-1693.

-----, D. C. Blacklund, and J. Haffner. 1998. The Miocene macroflora of the northern Ogallala Group, northern Nebraska and southern South Dakota. Journal of Paleontology 72: 388-397.

Galloway, J. et al. 2012. Correlating middle Cretaceous palynololgical records from the Canadian High Arctic based on a section from the Sverdrup Basin and samaples from the Eclipse Trough. Palynology 36: 277-302.

Gandolfo, M. 1996. The presence of Fagaceae (oak family) in sediments of the Klondike Mountain Formation (middle Eocene), Republic, Washington. Washington Geology 24: 20-21.

----- and R. N. Cúneo. 2005. Fossil Nelumbonaceae from the La Colonia Formation (Campanian-Maastrichtian, Upper Cretaceous), Chubut, Patagonia, Argentina. Review of Palaeobotany and Palynology 133: 169-178.

-----, E. J. Hermsen, M. C. Zamaloa, K. C. Nixon, C. C. González, P. Wilf, N. Rubén Cúneo, and K. R. Johnson. 2011. Oldest known *Eucalyptus* macrofossils are from South America. PLoS One (on-line, open-access journal; http://www/plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0021084).

-----, K. C. Nixon, and W. L. Crepet. 2000. Monocotyledons: A review of their Early Cretaceous record. In: K. L. Wilson and D. A. Morrison (eds.), Monocots: Systematics

and Evolution, pp. 44-51. CSIRO, Melbourne.

-----, D. W. Stevenson, and E. M. Friis. 1998. Oldest known fossils of monocotyledons. Nature 394: 532-533.

----- and E. J. Romero. 1990. Fossil remains of *Nothofagus* and other plants in Quaternary sediments of Gable Island, Tierra del Fuego, Argentina. In J. Rabassa (ed.), Quaternary of South America and Antarctic Peninsula, pp. 365-374. A. A. Balkema, Rotterdam.

Gayó, E., L. F. Hinojosa, C. Villagrán. 2005. On the presence of tropical paleofloras in central Chile during the early Eocene. Review of Palaeobotany and Palynology 137: 41-50.

Gengler-Nowak, K. 2002. Reconstruction of the biogeographical history of Malesherbiaceae. Botanical Review 68: 171-188.

Germeraad, J. H., C. A. Hopping, and J. Muller. 1968. Palynology of Tertiary sediments from tropical areas. Review of Palaeobotany and Palynology 6: 189-348.

Ghosh, P. K. and S. K. Roy. 1979. *Chisochetonoxylon benegalensis* gen. et sp. nov., a new fossil wood of Meliaceae from the Tertiary beds of Birbhum District, West Bengal, India. Current Science 48: 48: 737-739.

Givnish, T. J., K. C. Millam, T. M. Evans, J. C. Hall, J. C. Pires, P. E. Berry, and K. J. Sytsma. 2004. Ancient vicariance or recent long-distance dispersal? Inferences about phylogeny and South American-African disjunctions in Rapateaceae and Bromeliaceae based on *ndh*F sequence data. International Journal of Plant Sciences 165: 535-554.

----- (+ 18 authors). 2011. Phylogeny, adaptive radiation, and historical biogeography in Bromeliaceae: Insights from an eight-locus plastid phylogeny. American Journal of

Botany 98: 872-895.

Gómez-Laurito, J. and L. D. Gómez P. 1989. *Ticodendrron*: A new tree from Central America. Annals of the Missouri Botanical Garden 76: 1148-1151.

Gómez-Navarro, C., C. Jaramillo, F. Herrera, S. L. Wing, and R. Callejas. 2009. Palms (Arecaceae) from a Paleocene rainforest of northern Colombia. American Journal of Botany 96: 1300-1312.

Gonzalez, C. C., M. A. Gandolfo, M. C. Zamaloa, N. R. Cúneo, P. Wilf, and K. R. Johnson. 2007. Revision of the Proteaceae macrofossil record from Patagonia, Argentina. Botanical Review 73: 235-266.

González Guzmán, A. E. 1967. A palynological study on the upper Los Cuervos and Mirador formations (Lower and Middle Eocene, Tibú area, Columbia). E. J. Brill, Leiden.

Gooch, N. L. 1992. Two new species of *Pseudolarix* Gordon (Pinaceae) from the middle Eocene of the Pacific Northwest. PaleoBios 14: 13-19.

Goodson, B. E., S. K. Rehman, and R. K. Jansen. 2011. Molecular systematics and biogeography of *Descurainia* (Brassicaceae) based on nuclear ITS and non-coding Chloroplast DNA. Systematic Botany 36: 957-980.

Graham, A. 1962. *Ficus ceratops* Knowlton and its affinities with the living genus *Guarea*. Journal of Paleontology 36: 521-523.

-----. 1973. Literature on vegetational history in Latin America. In: A. Graham (ed.), Vegetation and Vegetational History of Northern Latin America, pp. 315-360. Elsevier, Amsterdam.

-----. 1973a. History of the arborescent temperate element in the Latin American biota.

In: A. Graham (ed.), Vegetation and Vegetational History of Northern Latin America, pp. 223-236. Elsevier, Amsterdam.

------. 1976. Studies in neotropical paleobotany. II. The Miocene communities of Veracruz, Mexico. Annals of the Missouri Botanical Garden 63: 787-842.

-----. 1976a. Late Cenozoic evolution of tropical lowland vegetation in Veracruz, Mexico. Evolution 29: 723-735.

-----. 1979. Literature on vegetational history of northern Latin America. Supplement I. Review of Palaeobotany and Palynology 27: 29-52.

-----. 1982. Literature on vegetational history of northern Latin America. Supplement II. Review of Palaeobotany and Palynology 37: 185-223.

-----. 1985. Studies in neotrorpical paleobotany. IV. The Eocene communities of Panama. Annals of the Missouri Botanical Garden 72: 504-534.

-----. 1986. Literature on vegetational history of northern Latin America. Supplement III. Review of Palaeobotany and Palynology 48: 199-239.

-----. 1989. Studies in neotropical paleobotany. VII. The lower Miocene communities of Panama—the La Boca Formation. Annals of the Missouri Botanical Garden 76: 50-66.

-----. 1991. Studies in neotropical paleobotany. IX. The Pliocene communities of Panama—angiosperms (dicots). Annals of the Missouri Botanical Garden 78: 201-223.

-----. 1991. Studies in neotropical paleobotany. X. The Pliocene communities of Panama- composition, numerical representations, and paleocommunity paleoenvironmental reconstructions. Annals of the Missouri Botanical Garden 78: 465-475.

-----. 1992. The current status of the legume fossil record in the Caribbean region. In: P.

S. Herendeen and D. L. Dilcher (eds.), Advances in Legume Systematics: Part 4. The Fossil Record, pp. 161-167. Royal Botanic Gardens, Kew.

-----. 1996. A contribution to the geologic history of the Compositae. In: D. J. N. Hind and H. J. Beentje (eds.), Compositate: Systematics. Proceedings of the International Compositae Conference (Royal Botanic Gardens, Kew, 1994), D. J. N. Hind (Editor-in-Chief), Vol 1, pp. 123-140.

-----. 1999. Studies in neotropical paleobotany. XIII. An Oligo-Miocene palynoflora from Simojovel (Chiapas, Mexico). American Journal of Botany 86: 17-31.

-----. 1999a. Late Cretaceous and Cenozoic History of North American Vegetation. Oxford University Press, Oxford, U.K.

-----. 2008/2009. Fossil record of the Rubiaceae. Annals of the Missouri Botanical Garden 96: 90-108.

-----. 2010. Late Cretaceous and Cenozoic History of Latin American Vegetation and Terrestrial Environments. Missouri Botanical Garden Press, St. Louis, MO.

-----. 2011. The age and diversification of terrestrial New World ecosystems through Cretaceous and Cenozoic time. American Journal of Botany, Special Issue on Biodiversity (P. H. Raven, J. M.. Chase, and J. C. Pires, Special Issue editors) 98: 336-351.

-----. 2011a. A Natural History of the New World, the Ecology and Evolution of Plants in the Americas. Univrsity of Chicago Press, Chicago.

----- and D. L. Dilcher. 1989. Studies in neotropical paleobotany. XII. A palynoflora from the Pliocene Rio Banano Formation of Costa Rica and the Neogene vegetation of Mesoamerica. American Journal of Botany 85: 1426-1438.

----- and -----. 1995. The Cenozoic record of tropical dry forest in northern Latin America and the southern United States. In: S. H. Bullock, H. A. Mooney, and A. Medina (eds.), Seasonally Dry Tropical Forests, pp. 124-145. Cambridge University Press, Cambridge.

----- and S. A. Graham. 1971. The geologic history of the Lythraceae. Brittonia 23: 335-346.

----- and D. M. Jarzen. 1969. Studies in neotropical paleobotany. I. The Oligocene communities of Puerto Rico. Annals of the Missouri Botanical Garden 56: 308-357.

Graham, S. A. 2013. Fossil records in the Lythraceae. Botanical Review 79: 48-145.

Grass Phylogeny Working Group (GPWG). 2001. Phylogeny and subfamilian classification of the grasses (Poaceae). Annals of the Missouri Botanical Garden 88: 373-457.

Green, A. F., T. S. Ramsey, and J. Ramsey. 2011. Phylogeny and biogeography of ivies (*Hedrea* spp., Araliaceae), a polyploidy complex of woody vines. Systematic Botany 36: 1114-1127.

Greenwood, D. R., K. B. Pigg, J. F. Basinger, and M. L. DeVore. 2016. A review of paleobotanical studies of the early Eocene Okanagan (Okanogan) Highlands floras of British Columbia, Canada, and Washington, USA. Canadian Journal of Earth Sciences 53:548-564.

Gregory, K. M. & W. C. McIntosh. 1996. Paleoclimate and paleoelevation of the Oligocene Pitch-Pinnacle flora, Sawatch Range, Colorado. Geological Society of America Bulletin 108: 545-561.

Griener, K. W., D. M. Nelson, and S. Warmy. 2013. Declining moisture availability on

the Antarctic Peninsula during the late Eocene. Palaeogeography, Palaeoclimatology, Palaeoecology 383-384: 72-78.

Grímsson, F. and T. Denk. 2005. *Fagus* from the Miocene of Iceland: Systematics and biogeographical consideratons. Review of Palaeobotany and Palynology 134: 27-54.

----- and -----. 2007. Floristic turnover in Iceland from 15 to 6 Ma—extracting biogeographical signals from fossil floral assemblages. Journal of Biogeography 34: 1490-1504.

-----, -----, and L. A. Simonarson. 2007. Middle Miocene floras of Iceland—the early colonization of an island? Review of Palaeobotanyand Palynology 144: 181-219.

------, R. Zetter, and C.-C. Hoffman. 2011. *Lythrum* and *Peplis* from the Late Cretaceous and Cenozoic of North America and Eurasia: New evidence suggesting early diversification within the Lythraceae. American Journal of Botany 98: 1815-2011.

-----, -----, G. W. Grimm, G. K. Pedersen, A. K. Pedersen, and T. Denk. 2015. Fagaceae pollen from the early Cenozoic of West Greenland: revisiting Engler's and Chaney's Arcto-Tertiary hypotheses. Plant Systematics and Evolution 301: 809-832.

-----, R. -----, and Q. Leng. 2012. Diverse fossil Onagraceae pollen from a Miocene palynoflora of north-east China: Early steps in resolving the phytogeographic history of the family. Plant Systematics and Evolution 298: 671-687.

Guinet, P. and I. K. Ferguson. 1989. Structure, evolution, and biology of pollen in the Leguminosae. In: C. H. Stirton and J. L. Zarucchi (eds.), Advances in Legume Biology. Missouri Botanical Garden Monographs in Systematic Botany 29: 77-103.

Gussarova, G., I. Greve Alsos, and C. Brochmann. 2012. Annual plants colonizing the Arctic? Phylogeography and genetic variation in the *Euphrasia minima* complex

(Orobanchaceae). Taxon 61: 146-160.

Gustafsson. A. L. S., C. F. Verola, and A. Antonelli. 2010. Reassessing the temporal evolution of orchids with new fossils and a Bayesian relaxed clock, with implications for the diversification of the rare South American genus *Hoffmannseggella* (Orchidaceae: Epidendroideae). BMC Evolutionary Biology 201010: 177. doi 10.1186/1471-2148-10-177.

Haggard, K. K. and B. H. Tiffney. 1997. The flora of the early Miocene Brandon Lignite, Vermont, USA. VIII. *Caldesia* (Alismataceae). American Journal of Botany 84: 239-252.

Hall, S. A. 2010. Early maize pollen from Chaco Canyon, New Mexico, USA. Palynology 34: 125-137.

Hammel, B. and W. G. Burger. 1991. Neither oak nor alder, but nearly: The history of Ticodendraceae. Annals of the Missouri Botanical Garden 78: 89-95.

Hansen, B. C. S., E. C. Grimm, and W. A. Watts. 2001. Palynology of the Peace Creek site, Polk County, Florida. Geological Society of America Bulletin 113: 682-692.

Harley, M. M. 2006. A summary of fossil records for Arecaceae. Botanical Journal of the Linnean Society 151: 39-67.

Hasenstab-Lehman, K. E. and M. G. Simpson. 2012. Cat's eyes and popcorn flowers: Phyloenetic systematics of the genus *Cryptantha* s.l. (Boraginaceae). Systematic Botany 37: 738-757.

Hawkes, J. G. 1990. The Potato: Evolution, Biodiversity and Genetic Resources. Belhaven Press, Oxford.

Hearn, D. J. 2006. *Adensia* (Passifloriaceae) and its adaptive radiation: Phylogeny and

growth form diversification. Sysematic Botany 31: 805-821.

Heibl, C. and S. S. Renner. 2012. Distribution models and a dated phylogeny for Chilean *Oxalis* species reveal occupation of new habitats by different lineages, not rapid adaptive radiation. Systematic Biology 61: 823-834.

Herendeen, P. S. 1991. Lauraceous wood from the mid-Cretaceous Potomac Group of eastern North America: *Paraphyllanthoxylon marylandense* sp. nov. Review of Palaeobotany and Palynology 69: 277-290.

-----. 1992. The fossil record of the Leguminosae from the Eocene of southeastern North America. In: P. S. Herendeen and D. L. Dilcher (eds.), Advances in Legume Systematics: 4. The Fossil Record, pp. 85-160. Royal Botanic Gardens, Kew.

----- and P. R. Crane. 1995. The fossil history of the monocotyledons. In: P. J. Rudall, P. J. Cribb, D. F. Cutler, and C. J. Humphries (eds.), Monocotyledons: Systematics and Evolution, pp. 1-21. Royal Botanic Gardens, Kew.

-----, -----, and A. N. Drinnan. 1995. Fagaceous flowers, fruits and cupules from the Campanian (Late Cretaceous) of central Georgia, USA. International Journal of Plant Sciences 156: 93-116.

-----, W. L. Crepet, and K. C. Nixon. 1993. *Chroranthus*-like stamens from the Upper Cretaceous of New Jersey. American Journal of Botany 80: 865-871.

-----, -----, and -----. 1994. Fossil flowers and pollen of Lauraceae from the Upper Cretaceous of New Jersey. Plant Systematics and Evolution 189: 29-40.

----- and D. L. Dilcher. 1990. *Diplotropis* (Leguminosae, Papilionoideae) from the middle Eocene of southeastern North America. Systematic Botany 15: 526-533.

----- and -----. 1990. Reproductive and vegetative evidence for the occurrence of *Crudia*

(Leguminosae, Caesalpinioideae) in the Eocene of southeastern North America. Botanical Gazette 151: 402-413.

Herendeen, P. S. and F. Herrera. 2019. Eocene fossil legume leaves referable to the extant genus *Arcoa* (Caesalpinioideae, Leguminosae). International Journal of Plant Sciences 180: 220-231.

-----, D. H. Les, and D. L. Dilcher. 1990. Fossil *Ceratophyllum* (Ceratophyllaceae) from the Tertiary of North America. American Journal of Botany 77: 7-16.

-----, S. Magallón-Puebla, R. Lupia, P. R. Crane, and J. Kobylinska. 1999. A preliminary conspectus of the Allon flora from the Late Cretaceous (late Santonian) of central Georgia, USA. Annals of the Missouri Botanical Garden 86: 407-471.

Hermsen, E. J. and M. A. Gandolfo. 2016. Fruits of Juglandaceae from the Eocene of South America. Systematic Botany 41: 316-328.

Hernandez-Castillo, G. R., R. A. Stockey, and G. Beard. 2005. Taxodiaceous pollen cones from the Early Tertiary of British Columbia, Canada. International Journal of Plant Sciences 166: 339-346.

-----, -----, and G. W. Rothwell. 2006. *Anemia quatsinoensis* sp. nov. (Schizaeaceae), a permineralized fern from the Lower Cretaceous of Vancouver Island. International Journal of Plant Sciences 167: 665-674.

Herrera F. A., C. A. Jaramillo, D. L. Dilcher, S. L. Wing, and C. Gómez-N. 2008. Fossil Araceae from a Paleocene neotropical rainforest in Colombia. American Journal of Botany 95: 1569-1583.

-----, S. R. Manchester, S. B. Hoot, K. M. Wefferling, M. R. Carvalho, and C. Jaramillo.

2011.Phytogeographic implications of fossil endocarps of Menispermaceae from the Paleocene of Colombia. American Journal of Botany 98: 2004-2017.

-----, -----, and C. Jaramillo. 2012. Permineralized fruits from the late Eocene of Panama give clues of the composition of forests established early in the uplift of Central America. Review of Palaeobotany and Palynology 175: 10-24.

-----, -----, -----, B. MacFadden, and S. A. de Silva-Caminha. 2010. Phytogeographic history and phylogeny of the Humiriaceae. International Journal of Plant Sciences 171: 392-408.

-----, -----, R. Koll, and C. Jaramillo. 2014. Fruits of *Oreomunnea* (Juglandaceae) in the eary Miocene of Panama. In: W. D. Stevens, O. M. Montiel, and P. H. Raven (eds.), Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th Year. Missouri Botanical Garden Press, St. Louis. Pp. 124-133.

Hickey, L. J. 1977. Stratigraphy and Paleobotany of the Golden Valley Formation (Early Tertiary) of Western North Dakota. Geological Society of America Memoir 150. Geological Society of America, Boulder, CO.

----- and J. A. Doyle. 1977. Early Cretaceous fossil evidence for angiosperm evolution. Botanical Review 43: 3-104.

-----and R. K. Peterson. 1978. *Zingiberopsis*, a fossil genus of the ginger family from Late Cretaceous to early Eocene sediments of Western Interior North America. Canadian Journal of Botany 56: 1136-1152.

Hill, R. S. 2001. Biogeography, evolution and palaeoecology of *Nothofagus* (Nothofagaceae): The contribution of the fossil record. Australian Journal of Botany 49: 321-332.

----- and G. J. Jordan. 1993. The evolutionary history of *Nothofagus* (Nothofagaceae). Australian Systematic Botany 6: 111-126.

----- and J. Read. 1991. A revised infragenetic classification of *Nothofagus* (Fagaceae). Botanical Journal of the Linnean Society 105: 37-72.

Hoffman, G. L. and R. A. Stockey. 1994. Sporophytes, megaspores, and massulae of *Azolla stanleyi* from the Paleocene Joffre Bridge locality, Alberta. Canadian Journal of Botany 72: 301-308.

----- and -----. 1999. Geological setting and paleobotany of the Joffre Bridge Roadcut fossil locality (late Paleocene), Red Deer Valley, Alberta. Canadian Journal of Earth Sciences 36: 2073-2084.

Hollick, A. 1927. The flora of the Saint Eugene silts, Kootenay Valley, British Columbia. Memoirs of the New York Botanical Garden 7: 389-428.

-----. 1936. The Tertiary floras of Alaska. U. S. Geological Survey Professional Paper 182: 1-185.

----- and G. C. Martin. 1930. The Upper Cretaceous Flora of Alaska. U. S. Geological Survey Professional Paper 159: 1-230.

Holmes, P. L. (ed.). 1991. The plant fossil record database, version 1.0. International Organization of Palaeobotany, London.

Hooghiemstra, H. 1984. Vegetational and climatic history of the High Plain of Bogotá, Colombia: A continuous record of the last 3.5 million years. Dissertationes Botanicae 79: 1-368.

-----. 1995. Environmental and palaeoclimatic evolution in late Pliocene-Quaternary Colombia. In: E. S. Verba, G. H. Denton, T. C. Partridge, and L. H. Burckle (eds.),

Paleoclimate and Evolution, with Emphasis of Human Origins, pp. 249-261. Yale University Press, New Haven.

Hoot, S. B., K. M. Meyer, and J. C. Manning. 2012. Phylogeny and reclassification of *Anemone* (Ranunculaceae), with an emphasis on austral species. Systematic Botany 37: 139-152.

Hu, S., D. L. Dilcher, H. Schneider, and D. M. Jarzen. 2006. Eusporangiate ferns from the Dakota Formation, Minnesota, U.S.A. International Journal of Plant Sciences 167: 579-589.

Huang, J. and R. A. Price. 2003. Estimation of the age of extant *Ephedra* using chloroplast *rbc*L sequence data. Molecular Biology and Evolution 20: 435-440.

Huang, T. C. 1980. Miocene palynomorphs of Taiwan. V. Angiosperm grains. Taiwania 25: 57-103.

Huertas, G. 1977. Una Melastomatácea fosil del Terciario carbónifero de Antioquina (Eoceno). Caldasia 12: 35-39.

Ickert-Bond. S. M., K. B. Pigg, and M. L. DeVore. 2015. *Paleochna tiffneyi* gen. et sp. nov. (Ochnaceae) from the late Paleocene Almont/Beicegel Creek Flora, North Dakota, USA. International Journal of Plant Sciences 176: 892-900.

-----, S. M. and C. Rydin. 2011. Micromorphology of the seed envelope of *Ephedra* L.(Gnetales) and its relevance for the timing of evolutionary events. International Journal of Plant Sciences 172: 36-48.

-----, -----, and S. S. Renner. 2009. A fossil-calibrated relaxed clock for *Ephedra* indicates an Oligocene age for divergence of Asian and New World clades and Miocene dispersal into South America. Journal of Systematics and Evolution 47:

444-456.

Iglesias, A. P., P. Wilf, K. R. Johnson, A. B. Zamuner, N. R. Cúneo, S. D. Matheos, and B. S. Singer. 2007. A Paleocene lowland macroflora from Patagonia reveals significantly greater richness than North American analogs. Geology 35: 947-950.

Iljinskaja, J. 1974. *Trochodendroides* Berry, *Nyssidium* Heer. In: A. Takhtajan (ed.), Magnoliophyta Fossilia URSR. I. Magnoliaceae-Eucommiaceae, pp. 112-124. Nauka, Leningrad. [In Russian].

Jabaily, R. S. and K. J. Sytsma. 2013. Historical biogeography and life-history evolution of Andean *Puya* (Bromeliaceae). Botanical Journal of the Lineana Society 171: 201-224.

Jacobs, B. F. and C. H. S. Kabuye. 1987. A middle Miocene (12.2 my old) forest in the East African Rift Valley, Kenya. Journal of Human Evolution 16: 147-155.

-----, J. D. Kingston, and L. L. Jacobs. 1999. The origin of grass-dominated ecosystems. Annals of the Missouri Botanical Garden 86: 590-643.

Jacques, F. M. B. 2009. Fossil history of the Meninspermaceae (Ranunculales). Annales de Paléontologie 95: 53-69.

----- et al. (+ 5 authors). 2011. Integrating fossils in a molecular-based phylogeny and testing them as calibration points for divergence time estimates in Menispermaceae. Journal of Systematics and Evolution 49: 25-49.

Jahnichen, H., D. H. Mai, and H. Walther. 1980. Blätter und Früchte von *Cerdidiphyllum* Siebold & Zuccarini im mitteleuropäischen Tertiär. Geologische Wissenschaften, Berlin: 16: 357-399.

Jan-du-Chene, R. E., M. S. Onyike, and M. A. Sowunmi. 1978. Some new Eocene

pollen of the Ogwashi-Asaba Formation, southeastern Nigeria. Revista Española de Micropaleontologia 10: 285-322.

Janssen, T. and K. Bremer. 2004. The age of major monocot groups inferred from 800+ *rbcL* sequences. Botanical Journal of the Linnean Society 146: 385-398.

Jaramillo, C., et al. (+ 12 authors). 2014. Palynological record of the last 20 million years in Panama. In: W. D. Stevens, O. M. Montiel, and P. H. Raven (eds.), Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th year. Missouri Botanical Garden Press, St. Louis. Pp. 134-251.

Jarzen, D. M. 1980. The occurrence of *Gunnera* pollen in the fossil record. Biotropica 12: 117-123.

----- and M. E. Dettmann. 1989. Taxonomic revision of *Tricolpites reticulatus* Cookson ex Cooper, 1953 with notes on the biogeography of *Gunnera* L. Pollen et Spores 31: 97-112.

Jiménez-Mejías, P. et al. 2016. A commented synopsis of the pre-Pleistocene fossil record of *Carex* (Cyperaceae). Botanical Review 82: 258-345.

Johnson, K. R. 2002. Megaflora of the Hell Creek and lower Fort Union Formations in the western Dakotas: Vegetational response to climate change, the Cretaceous-Tertiary boundary event, and rapid marine transgression. In: J. H. Hartman, K. R. Johnson, and D. J. Nichols (eds.), The Hell Creek Formation and the Cretaceous-Tertiary boundary in the northern Great Plains: An integrated continental record of the end of the Cretaceous. Geological Society of America Special Paper 361. Boulder, CO.

Jud, N. A., M. A. Gandolfo, A. Iglesias, and P. Wilf. 2017. Flowering after disaster: early Danian buckthorn (Rhamnaceae) flowers and leaves from Patagonia. Plos One,

https://doi.org/10.1371/journal.pone.0176164, May 10, 2017.

----- and L. J. Hickey. 2013. *Potomacarpnos apeleutheron* Gen. et Sp. Nov., a new Early Cretaceous angiosperm from the Potomac Group and its implications for the evolution of eudicot leaf architecture. American Journal of Botany 100: 2437-2449.

----- and C. W. Nelson. 2017. A liana from the lower Miocene of Panama and the fossil record of Connaraceae. American Journal of Botany 104:685-693.

-----, -----, and F. Herrera. 2016. Fruits and wood of *Parinari* from the early Miocene of Panama and the fossil record of Chrysobalanaceae. American Journal of Botany 103: 277-289.

Kadereit, J. W. and B. G. Baldwin. 2012. Western Eurasian-western North American disjunct plant taxa: The dry-adapted ends of formerly widespread north temperate mesic lineages—and examples of long-distance dispersal. Taxon 61: 3-17.

Kaehler, M. F. A. Michelangeli, and L. G. Lohmann. 2012. Phylogeny of *Lundia* (Bignoniaceae) based on *ndhF* and *PepC* sequences. Taxon 61: 368-380.

Karafit, S. J., G. W. Rothwell, R. A. Stockey, and H. Nishida. 2006. Evidence for sympodial vascular architecture in a filicalean fern rhizome: *Dickwhitea allenbyensis* gen. et sp. nov. (Athyriaceae). International Journal of Plant Sciences 167: 721-727.

----- and R. A. Stockey. 2008. *Paralygodium meckertii* sp. nov. (Schizaeaceae) from the Upper Cretaceous (Coniacian) of Vancouver Island, British Columbia, Canada. Review of Palaeobotany and Palynology 149: 163-173.

Katinas, L., J. V. Crisci, M. Tellería, V. Barreda, and L. Palazzesi. 2007. Early history of Asteraceae in Patagonia: Evidence from fossil pollen grains. New Zealand Journal of Botany 45: 605-610.

Kennedy, J. P. et al. 2016. Postglacial expansion pahtways of red mangrove, *Rhizophora mangle*, in the Caribbean Basin and Florida. American Journal of Botany 103: 260-276.

Kistler, L. et al. 2014. Transoceanic drift and the domestication of African bottle gourds in the Americas. Proceedings of the National Academy of Sciences USA 111:2937-2941.

Kittle, A., M. L. DeVore, B. Wall, and K. B. Pigg. 2005. *Acer* fruits from the Paleocene of North Dakota. Georgia Journal of Science 63: 32.

Klymiuk, A. A., R. A. Stockey, and G. W. Rothwell. 2011. The first organismal concept for an extint species of Pinaceae: *Pinus arnoldii* Miller. International Journal of Plant Sciences 172: 294-313.

Knight, C. L. and P. Wilf. 2013. Rare leaf fossils of Monimiaceae and Atherospermataceae (Lauraaaales) from Eocene Patagonian rainforests and their biogeographic significance. Palaeontologia Electronica 16(3), 26A; 39 p.

Knobloch, E. and D. H. Mai. 1984. Neue Gattungen nach Früchten und Samen aus dem Cenoman bis Maastricht (Kreide) von Mittleuropa. Feddes Repertorium 95: 3-41.

----- and -----. 1986. Monographie der Fruchte und Samen in der Kreide von Mittleuropa. Rozpravy ústredního Ustavu Geologickenhom, Praha 47: 1-219.

Koch, M. A. 2012. Mid-Miocene divergence of *Ionopsidium* and *Cochlearia* and its impact on the systematics and biogeography of the tribe Cochlearieae (Brassicaceae). Taxon 61: 76-92.

Krosnick, S. E., K. E. Porter-Utley, J. M. MacDougal, P, M. Jørgensen, and L. A. McDade. 2013. New insights into the evolution of *Passiflora* subgenus *Decaloba*

(Passifloraceae): Phylogenetic relationships and morphological synapomorphies. Systematic Botany 38: 692-713.

Kunzmann, L., B. A. R. Mohr, and M. E. C. Bernardes-de-Oliveira. 2004. Gymnosperms from the Lower Cretaceous Crato Formation (Brazil). I. Araucariaceae and *Lindleycladus* (incertae sedis). Mitteilungen aus dem Museum fűr Naturkunde in Berlin, Geowissenschaftliche Reihe 7: 155-174.

Kvaček, J. 1992. Lauralean angiosperms in the Cretaceous. Courier Froschungsinstitut Senckenberg 147: 345-367.

----- and C. Bůžek. 1995. Endocarps and foliage of the flowering plant family Icacinaceae from the Tertriary of Europe. Tertiary Research 15: 121-138.

-----, -----, and S. R. Manchester. 1991. Fossil fruits of *Pteleaecarpum* Weyland—tiliaceous, not sapindaceous. Botanical Gazette 152: 522-523.

----- and S. R. Manchester. 1999. *Eostangeria* Barthel (extinct Cycadales) from the Paleogene of western North America and Europe. International Journal of Plant Sciences 160: 621-629.

-----, -----, and M. A. Akhmetiev. 2005. Review of the fossil history of *Craigia* (Malvaceae s.l.) in the Northern Hemisphere based on fruits and co-occurring foliage. In: M. A. Akhmetiev and A. B. Herman (eds), Modern Problems of Palaeofloristics, Palaeophytogeography, and Phytostratigraphy, pp. 114-140. GEOS, Moscow.

----- and H. Walther. 1989. Paleobotanical studies in Fagaceae of the European Tertiary. Plant Systematics and Evolution 162: 213-229.

LaMotte, R. S. 1952. Catalogue of the Cenozoic Plants of North America through 1950.

Geological Society of America Memoir 51:1-381.

Landrum, L. R. 1981. The phylogeny and geography of *Myrceugenia* (Myrtaceae). Brittonia 33: 105-129

Lantz, T. C., G. W. Rothwell, and R. A. Stockey. 1999. *Conantiopteris schuchmanii,* gen. et sp. nov., and the role of fossils in resolving the phylogeny of Cyatheaceae s.l. Journal of Plant Research 112: 361-381.

Laport, R. G., R. L. Minckley, and J. Ramsey. 2012. Phylogeny and cytogeography of the North American creosote bush (*Larrea tridentata*, Zygophyllaceae). Systematic Botany 37: 153-164.

Lenhardt, N., M. Herrmann, and A. E. Götz. 2013. Palynomorph preservation in volcaniclastic rocks of the Miocene Tepoztlán Formation (central Mexico) and implications for paleoenvironmental reconstruction. Palaios 28: 710-723.

Leopold, E. B. 1984. Pollen identifications from the Eocene Chalk Bluffs flora, California. Abstract, Palynology 8: 8.

----- and S. Clay-Poole. 2001. Florissant leaf and pollen floras of Colorado compared: Climatic considerations. In E. Evanoff, K. M. Gregory-Wodzicki, and K. R. Johnson (eds.), Fossil Flora and Stratigraphy of the Florissant Formation, Colorado, pp. 17-69. Denver Museum of Nature & Science, Series 4, 1: 17-69.

----- and H. D. MacGinitie. 1972. Development and affinities of Tertiary floras in the Rocky Mountains. In A. Graham (ed.), Floristics and Paleofloristics of Asia and Eastern North America, pp. 147-200. Elsevier, Amsterdam.

----- and S. Zaborac-Reed. 2014. Biogeographic history of *Abies bracteata* (D. Don) Poit. in the western United States. In W. D. Stevens, O. M. Montiel., and P. H. Raven

(eds.), 2014. Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th Year. Missouri Botanical Garden Press, St. Louis. Pp. 252-286.

LePage, B. A. and J. F. Basinger. 1991. A new species of *Larix* (Pinaceae) from the Early Tertiary of Axel Heiberg Island, Arctic Canada. Review of Palaeobotany and Palynology 70: 89-111.

----- and -----. 1995a. The evolutionary history of the genus *Larix* (Pinaceae). U. S. Department of Agriculture, Forest Service, Intermountain Research Station, General Technical Report GTR-INT-319: 19-29.

----- and -----. 1995b. Evolutionary history of the genus *Pseudolarix* Gordon (Pinaceae). International Journal of Plant Sciences 156: 910-950.

Lesiak, M. A. 1994. Plant macrofossils from the middle Miocene of Lipnica Mala (Orawa-Nowy Targ Basin, Poland). Acta Palaeobotanica 34: 27-81.

Li, P. et al. (+ 6 authors). 2013. Phylogeography of North American herbaceous *Smilax* (Smilacaceae): Combined AFLP and cpDNA data support a northern refugium in the Driftless Area. American Journal of Botany 100: 801-814.

Li, R. and J. Wen. 2013. Phylogeny and biogeography of *Dendropanax* (Araliacerae), an amphi-Pacific disjunct genus between tropical/subtropical Asia and the neotropics. Systematic Botany 38: 536-551.

Li, Y., T. Smith, C.-J. Liu, N. Awasthi, J. Yang, Y.-F. Wang, and C.-S. Li. 2011. Endocarps of *Prunus* (Rosaceae: Prunoideae) from the early Eocene of Wutu, Shandong Province, China. Taxon 60: 555-564.

Lia, V. V., V. A. Confalonieri, C. I. Comas, and J. H. Hunziker. 2001. Molecular phylogeny of *Larrea* and its allies (Zygophyllaceae): Reticulate evolution and the

probable time of creosote bush arrival to North America. Molecular Phylogenetics and Evolution 21: 309-320.

Liede-Schumann, S., H. Kong, U. Meve, and M. Thiv. 2012. *Vincetoxicum* and *Tylophora* (Apocynaceae: Asclepiadoideae: Asclepiadeae)—two sides of the same medal: Independent shifts from tropical to temperate habitats. Taxon 61: 803-825.

Lima, M. R. and E. S. Amador. 1985. Análise palinológica de sedimentos de Formaçao Resende Terciário do estado de Rio de Janerio, Brasil. VIII Congreso Brasileiro de Paleontología, 1983, MME-DNPM, Ser. Geologia No. 27, Seçao Paleontología e Estratigrafía 2: 371-378.

----- and M. Salard-Cheboldaeff. 1981. Palynologie des basins de Gandarela et Fonseca (Eoceno de l'etat de Minas Gerais, Bresil). Boletin IG (Instituto Geociências), USP (Universidade São Paulo) 12: 33-54.

-----, -----, and K. Suguio. 1985a. Étude palynologique de la Formation Tremembé Tertiaire du Bassin de Taubaté (etat de São Paulo, Bresil) d'apres les échantillons du sondage No. 42 du CNP. VIII Congreso Brasileiro de Paleontología, 1983, MME-DNPM, Seçao Paleontología e Estratigrafía 2: 183-187.

-----, J. B. O. Vespucci, and K. Suguio. 1985b. Estudio palinológico de uma camada de linhito de Formaçao Cacapava, Bacia de Taubaté, Tertiario do eastado de São Paulo, Brasil. Anais Academia Brasileira Ciências 57: 183-187.

Limarino, C. O., M. G. Passalia, M. Llorens, E. I. Vera, V. S. Perez Loinaze, and S. N. Césari. 2012. Depositional environments and vegetation of Aptian sequences affected by volcanism in Patagonia. Palaeogeography, Palaeoclimatology, Palaeoecology 323-325: 22-41.

Link-Pérez, M., L. E. Watson, and R. James Hickey. 2011. Redefination of *Adiantopsis* Fée (Pteridaceae): Systematics, diversification, and biogeography. Taxon 60: 1255-1268.

Little, S. A. and R. A. Stockey. 2003. Vegetative growth of *Decodon allenbyensis* (Lythraceae) from the middle Eocene Princeton Chert with anatomical comparisons to *Decodon verticillatus*. International Journal of Plant Sciences 164: 453-469.

----- and -----. 2006. Morphogenesis of the specialized peridermal tissues in *Decodon allenbyensis* from the middle Eocene Princeton Chert. International Association of Wood Anatomists (IAWA) Journal 27: 73-87.

-----, -----, and R. C. Keating. 2004. *Duabanga*-like leaves from the middle Eocene Princeton Chert and comparative leaf histology of Lythraceae sensu lato. American Journal of Botany 91: 1126-1139.

-----, -----, and B. Penner. 2009. Anatomy and development of fruits of Lauraceae from the middle Eocene Princeton Chert. American Journal of Botany 96: 637-651.

-----, -----, and G. W. Rothwell. 2006. *Stramineopteris aureopilosus* gen. et sp. nov.: Reevaluating the role of vegetative anatomy in the resolution of leptosporangiate fern phylogeny. International Journal of Plant Sciences 167: 683-694.

Liu, B. et al. (+ 6 authors). 2018. Historical biogeography of Loranthaceae (Santalales): diversification agrees with emergence of tropical forests and radiation of songbirds. Molecular Phylogenetics and Evolution. 124: 199-212.

Liu, X., S. R. Manchester, and J. Jin. 2014. *Alnus* subgenus *Alnus* in the Eocene of western North America based on leaves, associated catkins, pollen and fruits. Amer. J. Bot. 101: 1925-1943.

Lobreau-Callen, D. and S. K. Srivastava. 1974. Paleocene occurrence of *Platea* (Icacinaceae) pollen in the U.S.A. Pollen et Spores XVI: 411-423.

Lohmann, L. G., C. D. Bell., M. Fernanda Calió, and R. G. Winkworth. 2013. Pattern and timing of biogeographical history in the Neotropical tribe Bignonieae (Bignoniaceae). Botanical Journal of the Linnean Society 171: 154-170.

Lorente, M. A. 1986. Palynology and Palynofacies of the Upper Tertiary in Venezuela. Dissertationes Botanicae, Band 99. J. Cramer, Berlin.

Lott, T. A., S. R. Manchester, and S. L. Corbett. 2019. The Miocene flora of Alum Bluff, Liberty County, Florida. Acta Palaeobotanica 59: 75-129.

Lu-Irving, P. and R. G. Olmstead. 2013. Investigating the evolution of Lantaneae (Verbenaceae) using multiple loci. Botanical Journal of the Linnean Society 171: 103-119.

Lucas, E. J., K. Matsumoto, S. A. Harris, E. M. Nic Lughadha, B. Benardini, and M. W. Chase. 2011. Phylogenetics, morphology, and evolution of the large genus *Myrcia* s.l. (Myrtaceae). International Journal of Plant Systematics 172: 915-934.

Luebert, F., H. H. Hilger, and M. Weigend. 2011. Diversification in the Andes: Age and origins of South American *Heliotropium* lineages (Heliotropiaceae, Boraginales). Molecular Phylogenetics and Evolution 61: 90-102.

Lupia, R., P. S. Herendeen, and J. A. Keller. 2002. A new fossil flower and associated coprolites: Evidence for angiosperm-insect interactions in the Santonian (Late Cretaceous) of Georgia, U.S.A. International Journal of Plant Sciences 163: 675-686.

Lutz, A. I. and L. Martínez. 2007. Nuevo género y especie de liana del Mioceno Superior (Formación Palo Pintado), provincial de Salta, Argentina. Ameghiniana 44:

205-213.

Mabberley, D. J., C. M. Pannell, and A. M. Sing. 1995. Meliaceae, Flora Malesiana, series I, Vol. 12, part 1. Rijksherbarium/Hortus Botanicus, Leiden University, Leiden.

MacGinitie. H. D. 1941. A Middle Eocene Flora from the Central Sierra Nevada. Carnegie Institution of Washington Publication 534. Washington, D.C.

-----. 1953. Fossil Plants of the Florissant Beds, Colorado. Carnegie Institution of Washington Publication 599. Washington, D.C.

-----. 1969. The Eocene Green River flora of northwestern Colorado and northeastern Utah. University of California Publications Geological Sciences 83: 1-203.

-----. 1974. An early Middle Eocene flora from the Yellowstone-Absaroka Volcanic Province, northwestern Wind River Basin, Wyoming. University of California Publications Geological Sciences 108: 1-103.

Mädel, E. 1962. Die fossilen Euphorbiaceen-Hölzer mit besonderer Berücksichtigung neuer Funde aus der Oberkreide Süd-Afrikas. Senkengergiana Lethaea 43: 283-321.

Magallón, S., P. R. Crane, and P. S. Herendeen. 1999. Phylogenetic pattern, diversity, and diversification of eudicots. Annals of the Missouri Botanical Garden 86: 297-372.

-----, P.S. Herendeen, and P. R. Crane. 1997. *Quadriplatanus georgianus* gen. et sp. nov.: Staminate and pistilate platanaceous flowers from the Late Cretaceous (Coniacian-Santonian) of Georgia, U.S.A. International Journal of Plant Sciences 158: 373-394.

-----, R. T. Pennington, J. L. Villaseñor, P. Rodríguez, E. N. H. Coronado, R. Foster, D. Harris, and J. Wieringa. 2014. The influence of regional history and ecological affinity in the angiosperm composition of Mexican lowland tropical rainforests. In: W. D.

Stevens, O. M. Montiel, and P. H. Raven (eds.), Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th year. Missouri Botanical Garden Press, St. Louis. Pp. 287-325.

Mai, D. H. 1971. Űber fossile Lauraceae und Theaceae in Mitteleuropa. Feddes Repertorium 82: 313-341.

-----. 1995. Tertiäre Vegetationsgeschichte Europa. G. Fischer, Jena.

-----. 1999. Die untermiozänen Floren aus der Spremberger Folge und dem II. Flözhorizont in der Lausitz , Teil II: Polycarpicae und Apetalae. Palaeontographica, Abt. B, 251: 1-70.

-----. 2000. Die untermiozänen Floren aus der Spremberger Folge und dem II. Flözhorizont der Lausitz. Teil III: Dialypetalae und Sympetalae. Palaeontographica, Abt. B, 253: 1-106.

-----. 2001. Die mittelmiozänen und obermiozänen floren aus der Meuroer und Raunoer Folge in der Lausitz, Teil II: Dicotyledonen. Palaeontographica, Abt. B, 257: 35-174.

----- and H. Walther. 1978. Die floren der Haselbacher Serie im Weisselster-Becken (Bezik Leipzig, DDR). Abhandlungen des Staatlichen Museums für Mineralogie und Geologie zu Dresden 28: 1-100.

Malik, S. et al. 2017. Phylogeny and biogeography of *Artemisia* subgenus *Seriphidium* (Asteraceae: Anthemideae). Taxon 66: 934-952.

Manchester, S. R. 1980. *Chattawaya* (Sterculiaceae): A new genus of wood from the Eocene of Oregon and its implications for xylem evolution of the extant genus *Pterospermum*. American Journal of Botany 67: 59-67.

-----. 1986. Vegetative and reproductive morphology of an extinct plane tree

(Platanaceae) from the Eocene of westerrn North America. Botanical Gazette 147: 200-225.

-----. 1987. The fossil history of the Juglandaceae. Missouri Botanical Garden Monographs in Systematic Botany 21: 1-137.

-----. 1989. Early history of the Juglandaceae. Plant Systematics and Evolution 162: 231-250.

-----. 1989. Systematics and fossil history of the Ulmaceae. In: P. R. Crane and S. Blackmore (eds.), Evolution, Systematics, and Fossil History of the Hamamelidae, Vol. 2, pp. 221-251. Claredon Press, Oxford.

-----. 1992. Flowers, fruits, and pollen of *Florissantia*, an extinct malvalean genus from the Eocene and Oligocene of western North America. American Journal of Botany 79: 996-1008.

-----. 1994. Fruits and seeds of the middle Eocene nut beds flora, Clarno Formation, Oregon. Palaeontographica Americana 58: 1-205.

-----. 1994. Inflorescence bracts of fossil and extant *Tilia* in North America, Europe, and Asia: Patterns of morphologic divergence and biogeographic history. American Journal of Botany 81: 1176-1185.

-----. 1999. Biogeographical relationships of North American Tertiary floras. Annals of the Missouri Botanical Garden 86: 472-522.

-----. 2000. Late Eocene fossil plants of the John Day Formation, Wheeler County, Oregon. Oregon Geology 62: 51-63.

-----. 2001. Update on the megafossil flora of Florissant, Colorado. In: E. Evanoff, K. M. Gregory-Wodzicki, and K. R. Johnson (eds.), Fossil Flora and Stratigraphy of the

Florissant Formation, Colorado. Denver Museum of Nature & Science, Series 4, 1: 137-162.

-----. 2001. Leaves and fruits of *Aesculus* (Sapindales) from the Paleocene of North America. International Journal of Plants Sciences 162: 985-998.

-----. 2002. Leaves and fruits of *Davidia* (Cornales) from the Paleocene of North America. Systematic Botany 27: 368-382.

-----. 2009. Taxonomic databases and their utility for paleobotany. International Organization of Palaeobotany (IOP) Newsletter 88: 14.

-----. 2011. Fruits of Ticodendraceae (Fagales) from the Eocene of Europe and North America. International Journal of Plant Sciences 172: 1179-1187.

-----, M. A. Akhmetiev, and T. M. Kodrul. 2002. Leaves and fruits of *Celtis apera* (Newberry) comb. nov. (Celtidaceae) from the Paleocene of North America and eastern Asia. International Journal of Plant Sciences 163: 725-736.

----- and Z.-D. Chen. 1996. *Palaeocarpinus aspinosa* sp. nov. (Betulaceae) from the Paleocene of Wyoming, U.S.A. International Journal of Plant Sciences 157: 644-655.

----- and -----. 1998. A new genus of Coryloideae (Betulaceae) from the Paleocene of North America. International Journal of Plant Sciences 159: 522-532.

-----, -----, A. M. Lu, and K. Uemura. 2009. Eastern Asian endemic seed plant genera and their paleogeographic history thoughout the Northern Hemisphere. Journal of Systematics and Evolution 47: 1-42.

-----, P. R. Crane, and D. L. Dilcher. 1991. *Nordenskioldia* and *Trochodendron* (Trochodendraceae) from the Miocene of northwestern North America. Botanical Gazette 152: 357-368.

-----, -----, and L. B. Golovneva. 1999. An extinct genus with affinities to extant *Davidia* and *Camptotheca* (Cornales) from the Paleocene of North America and eastern Asia. International Journal of Plant Sciences 160: 188-207.

----- and D. L. Dilcher. 1982. Pterocaryoid fruits (Juglandaceae) in the Paleogene of North America and their evolutionary and biogeographic significance. American Journal of Botany 69: 275-286.

----- and -----. 1997. Reproductive and vegetative morphology of *Polyptera* (Juglandaceae) from the Paleocene of Wyoming and Montana. American Journal of Botany 84: 649-663.

----, -----, and S. L. Wing. 1998. Attached leaves and fruits of myrtaceous affinity from the middle Eocene of Colorado. Review of Palaeobotany and Palynology 102: 153-163.

----- and R. M. Dillhoff. 2004. *Fagus* (Fagaceae) fruits, foliage, and pollen from the middle Eocene of Pacific northwestern North America. Canadian Journal of Botany 82: 1509-1517.

----- and E. J. Hermsen. 2000. Flowers, fruits, seeds, and pollen of *Landeenia* gen. nov., an extinct sapindalean genus from the Eocene of Wyoming. American Journal of Botany 87: 1909-1914.

----- and L. J. Hickey. 2007. Reproductive and vegetative organs of *Brownieae* gen. n. (Nyssaceae) from the Paleocene of North America. International Journal of Plant Sciences 168: 229-249.

----- and W. C. McIntosh. 2007. Late Eocene silicified fruits and seeds from the John Day Formation near Post, Oregon. PaleoBios 27: 7-17.

----- and E. L. O'Leary. 2010. Phylogenetic distribution and identification of fin-winged fruits. Botanical Review 76: 1-82.

-----, K. B. Pigg, and P. R. Crane. 2004. *Palaeocarpinus dakotensis* sp. n. (Betulaceae: Coryloideae) and associated staminate catkins, pollen, and leaves from the Paleocene of North Dakota. International Journal of Plant Sciences 165: 1135-1148.

----- and K. Uemura. 2013. *Ozakia*, a new genus of winged fruit shared between the Miocene of Japan and western North America. Journal of Plant Research, published online, DOI 10.1007/s10265-013-0602-2.

-----, V. Wilde, and M. E. Collinson. 2007. Fossil cashew nuts from the Eocene of Europe: Biogeographic links between Africa and South America. International Journal of Plant Sciences 168: 1199-1206.

-----, Q-Y. Xiang, T. M. Kodrul, and M. A. Akhmetiev. 2009. Leaves of *Cornus* (Cornaceae) from the Paleocene of North America and Asia confirmed by trichome characters. International Journal of Plant Sciences 170: 132-142.

----- and M. S. Zavada. 1987. *Lygodium* foliage with intact sorophores from the Eocene of Wyoming. Botanical Gazette 148: 392-399.

Manen, J.-F., M. C. Boulter, and Y. Naciri-Graven. 2002. The complex history of the genus *Ilex* L. (Aquifoliaceae): evidence from the comparison of plastid and nucear DNA sequences and from fossil data. Plant Systematics and Evolution 235:79-98.

Manos, P. S. 1997. Systematics of *Nothofagus* (Nothofagaceae) based on rDNA spacer sequences (ITS): Taxonomic congruence with morphology and plastid sequences. American Journal of Botany 84: 1137-1155.

-----, P. S. Soltis, D. E. Soltis, S. R. Manchester, S.-H. Oh, C. D. Bell, D. L. Dilcher, and

D. E. Stone. 2007. Phylogeny of extant and fossil Juglandaceae inferred from the integration of molecular and morphological data sets. Systematic Botany 56: 412-430.

Mao, K., R. I. Milne, L. Zhang, Y. Peng, J. Liu, P. Thomas, R. R. Mill, and S. S. Renner. 2012. Distribution of living Cupressaceae reflects the breakup of Pangea. Proceedings of the National Academy of Sciences USA 109: 7793-7798.

Martin, H. A. 2003. The history of the family Onagraceae in Australia and its relevancy to biogeography. Australian Journal of Botany 51: 585-598.

Martínez, C. 2017. Passifloraceae seeds from the late Eocene of Colombia. American Journal of Botany 104:1857-1866.

-----, M. R. Carvalho, S. Madriñán, and C. Jaramillo. 2015. A Late Cretaceous *Piper* (Piperaceae) from Colombia and diversification patterns for the genus. American Journal of Botany 102: 273-289.

-----, S. Madriñán, M. Zavada, and C. A. Jaramillo. 2013. Tracing the fossil pollen record of *Hedyosmum* (Chloranthaceae), an old lineage with recent Neotropical diversification. Grana 52: 161-180.

Martínez-Millán, M. 2010. Fossil record and age of the Asteridae. Botanical Review 76: 83-135.

Marx, H. E., N. O'Leary, Y.-W. Yuan, P. Lu-Irving, D. C. Tank, M. Múlgura, and R. G. Olmstead. 2010. A molecular phylogeny and classification of Verbenaceae. American Journal of Botany 97: 1647-1663.

Matthews, J. V., Jr. and L. E. Ovenden. 1990. Late Tertiary plant macrofossils from localities in Arctic/Subarctic North America: a review of the data. Arctic 43: 364-392.

Matthews, T., M. L. DeVore, and K. B. Pigg. 2006. Paleocene pteridophytes from the

siliceous shales of western North Dakota. Abstract, 23rd Annual Midcontinent Paleobotanical Colloquium, Florida Museum of Natural History, University of Florida, Gainesville, March 10-12.

-----, K. B. Pigg, M. L. DeVore, and J. Rhode. 2007. Anatomically preserved *Isoetes* from the Paleocene of North Dakota: Utility in ascertaining paleohabitat. Abstract with Programs, Geological Society of America 39: 29.

Mautino, L. R. and L. M. Anzotegui. 2014. Novedades palinológicas de las formaciones San José y Chiquimil (Mioceno medio y tardío), noroeste de Argentina. Revista del Museo Argentino Ciencias Naturales 16: 143-164.

McCartan, L. et al. (+ 7 authors). 1990. Late Tertiary floral assemblage from upland gravel deposits of the southern Maryland coastal plain. Geology 18: 311-314.

McClain, A. M., and S. R. Manchester. 2001. *Dipteronia* (Sapindaceae) from the Tertiary of North America and implications for the phytogeographic history of the Aceroideae. American Journal of Botany 88: 1316-1325.

McInnes, L, C. Orme, and A. Purvis. 2011. Detecting shifts in diversity limits from molecular phylogenies: What can we Know? Proceedings of the Royal Society B 278: 3294-3302.

McIver, E. E. and J. F. Basinger. 1993. Flora of the Ravenscrag Formation (Paleocene), southwestern Saskatchewan, Canada. Palaeontographica Canadiana 10: 1-167.

----- and -----. 1999. Early Tertiary floral evolution in the Canadian High Arctic. Annals of the Missouri Botanical Garden 86: 523-545.

McKown, A. D., R. A. Stockey, and C. E. Schweger. 2002. A new species of *Pinus* subgenus *Pinus* subsection *Contortae* from Pliocene sediments of Ch'ijee's Bluff,

Yukon Territory, Canada. International Journal of Plant Sciences 163: 687-697.

McMurran, D. M. and S. R. Manchester. 2010. *Lagokarpos lacustris*, a new winged fruit from the Paleogene of western North America. International Journal of Plant Sciences 171: 227-234.

Meller, B. 2006. Comparative investigation of modern and fossil *Toricellia* fruits- a disjunctive element in the Miocene and Eocene of Central Europe and the USA. Beiträge zur Paläontologie 30: 315-327.

Mello, C. L., L. G. Sant'Anna, and L. P. Bergqvist. 2000. The paleontological site of Fonseca, Minas Gerais state, Brazil (fossil plants of the Tertiary of Brazil). In: C. Schobbenhaus, D. A. Campos, E. T. Queíroz, M. Winge, and M. Berbert-Born (eds.), Sitos Geológicos e Paleontológicos do Brasil [online]. http://www.Unb.br/ig/sigep/sitio086/sitio086.htm [accessed 23 February, 2011].

Méon, H. and B. Tayech. 1986. Études palynologiques dan le Miocene du Cap Bon (Tunisie), essai d'establissement d'ecozones et de reconstitution paleogeographique. Geobios Lyon 19: 601-626.

Merckx, V.S.F.T. et al. (+ 6 authors). 2013. Phylogenetic relationships of the mycoheterotrophic genus *Voyria* and the implications for the biogeographic history of Gentianaceae. American Journal of Botany 100: 712-721.

Meyer, H. W. 2003. The Fossils of Florissant. Smithsonian Institution Press, Washington, D.C.

-----. 2005. *Metasequoia* in the Oligocene Bridge Creek flora of western North America: Ecological implications and the history of research. In: B. A. LaPage, C. J. Williams, and H. Yang (eds.), The Geobiology and Ecology of *Metasequoia*, pp. 159-

186. Springer, Berlin.

----- and S. R. Manchester. 1997. The Oligocene Bridge Creek flora of the John Day Formation, Oregon. University of California Publications Geological Sciences 141: 1-195.

Michelangeli, F. A., P. J. F. Guimaraes, D. S. Penneys, F. Almeda, and R. Kriebel. 2013. Phylogenetic relationships and distribution of New World Melastomeae (Melastomataceae). Botanical Journal of the Linnean Society 171: 38-60.

Mickle, J. 1996. *Grexupus carolinensis*, a new probable lauraceous fruit from the Late Cretaceous of North Carolina. Journal of the Elisha Mitchell Scientific Society 112: 1-6.

Millar, C. I. 1996. Tertiary vegetation history. Sierra Nevada Ecosystem Project: Final Report to Congress. Volume II, pp. 71-122. Center for Water and Wildland Resources. University of California, Davis

Miller, C. N., Jr.. 1989. A new species of *Picea* based on silicified seed cones from the Oligocene of Washington. American Journal of Botany 76: 747-754.

-----. 1990. Stems and leaves of *Cunninghamiostrobus goedertii* from the Oligocene of Washington. American Journal of Botany 77: 963-971.

Mindell, R. A., S. J. Karafit, and R. A. Stockey. 2014. Bisexual flowers from the Coniacian (Late Cretaceous) of Vancouver Island, Canada: *Ambiplatanus washingtonensis* gen. et sp. nov. (Platanaceae). Intetnational Journal of Plant Sciences 175: 651-662.

Mindell, R. A., R. A. Stockey, and G. Beard. 2006. Anatomically preserved staminate inflorescences of *Gynoplatananthus oysterbayensis* gen. et sp. nov. (Platanaceae) and

associated pistillate fructifications from the Eocene of Vancouver Island, British Columbia. International Journal of Plant Sciences 167: 591-600.

-----, -----, -----. 2007. *Cascadiacarpa spinosa* gen. et sp. nov. (Fagaceae): Castaneoid fruits from the Eocene of Vancouver Island, Canada. American Journal of Botany 94: 351-361.

-----, -----, and -----. 2009. Permineralized *Fagus* nuts from the Eocene of Vancouver Island, Canada. International Journal of Plant Sciences 170: 551-560.

-----, -----, G. W. Rothwell, and G. Beard. 2006. *Gleichenia appianensis* sp. nov. (Gleicheniaceae): A permineralized rhizome and associated vegetative remains from the Eocene of Vancouver Island, British Columbia. International Journal of Plant Sciences 167: 639-647.

Mohr, B. A. R. and M. E. C. Bernades-de-Oliveira. 2004. *Endressinia brasiliana*, a magnolialean angiosperm from the Lower Cretaceous Crato Formation (Brazil). International Journal of Plant Sciences 165: 1121-1133.

-----, -----, and D. W. Taylor. 2008. *Pluricarpellatia*, a nymphaealean angiosperm from the Lower Cretaceous of northern Gondwana (Crato Formation, Brazil). Taxon 57: 1147-1158.

-----and H. Eklund. 2003. *Araripia florifera*, a magnoliid angiosperm from the Lower Cretaceous Crato Formation (Brazil). Review of Palaeobotany and Palynology 126: 279-292.

----- and E. M. Friis. 2000. Early angiosperms from the Lower Cretaceous Crato Formation (Brazil), a preliminary report. International Journal of Plant Sciences 161 (supplement): S155-S167.

----- and D. B. Lazarus. 1994. Paleobiogeographic distribution of *Kuylisporites* and its possible relationship to the extant fern genus *Cnemidaria* (Cyatheaceae). Annals of the Missouri Botanical Garden 81: 758-767.

----- and C. Rydin. 2002. *Trifurcatia flabellata* n. gen. n. sp., a putative monocotyledon angiosperm from the Lower Cretaceous Crato Formation (Brazil). Mittlung Museum Naturkunde Berlin, Geowissenschaften Reihe 5: 335-344.

Moiseeva, M. G., A. B. Herman, and R. A. Spicer. 2009. Late Paleocene flora of the northern Alaska Peninsula: the role of transberingian plant migrations and climage change. Palaeontological Journal 43: 1298-1308.

Moore, M. J., A. Bartoli, R. D. Tortosa, and B. G. Baldwin. 2012. Phylogeny, biogeography, and chromosome evolution of the amphitropical genus *Grindelia* (Asteraceae) inferred from nuclear ribosomal and chloroplast sequence data. Taxon 61: 211-230.

Moore, M. J. and R. K. Jansen. 2006. Molecular evidence for the age, origin, and evolutionary history of the American desert plant genus *Tiquilia* (Boraginaceae). Molecular Phylogenetics and Evolution 39: 668-687.

Morley, R. J. and C. W. Dick. 2003. Missing fossils, molecular clocks, and the origin of the Melastomataceae. American Journal of Botany 90: 1638-1644.

Morris, A. B., S. M. Ickert-bond, D. B. Brunson, D. E. Soltis, and P. S. Soltis. 2008. Phylogeographical structure and temporal complexity in the American sweetgum (*Liquidambar stryaciflua*; Altingiaceae). Molecular Ecology 17: 3889-3900.

-----, C. H. Graham, D. E. Soltis, and P. S. Soltis. 2010. Reassesment of phylogeographical structure in eastern North American trees using Monmonier's

algorithm and ecological niche modeling. Journal of Biogeography 37: 1657-1667.

Mosbrugger, V. 1999. The nearest living relative method. In: T. P. Jones and N. P. Rowe (eds.), Fossil Plants and Spores, Modern Techniques, pp. 261-265. The Geological Society, London.

----- and T. Utescher. 1997. The coexistence approach-method for quantitative reconstructions of Tertiary terrestrial palaeoclimate data using plant fossils. Palaeogeography, Palaeoclimatology, Palaeoecology 134: 61-86.

Muellner, A. N., V. Savolainen, R. Samuel, and M. W. Chase. 2006. The mahogany family "out of Africa': Divergence time, estimation, global biogeographic patterns inferred from plastid *rbcL* DNA sequences, extant, and fossil distribution of diversity. Molecular Phylogenetics and Evolution 40: 236-250.

Muller, J. 1981. Fossil pollen records of extant angiosperms. Botanical Review 47: 1-142.

Müller, S. et al. 2015. Intercontinental long-distance dispersal of Canellaceae from the New to the Old World revealed by a nuclear single copy gene and chloroplast loci. Molecular Phylogenetics and Evolution 84: 205-219.

Narváez, P. L., N. Mego, and M. B. Prámparo. 2013. Cretaceous cicatricose spores from north and central-western Argentina: Taxonomic and biostratigraphical discussion. Palynology 37: 202-217.

Nauheimer, L., D. Metzler, and S. S. Renner. 2012. Global history of the ancient monocot family Araceae inferred with models accounting for past continental positions and previous ranges based on fossils. New Phytologist 195: 938-950.

Nelson, C. W. and N. A. Jud. 2017. Biogeographic implications of *Mammea*

paramericana sp. nov. from the lower Miocene of Panama and the evolution of Calophyllaceae. International Journal of Plant Sciences 178: 241-257.

Nichols, D. J. 1973. North American and European species of *Momipites* ("*Engelhardia*") and related genera. Geoscience and Man 7: 103-117.

Nicolas, A. N. and G. Plunkett. 2012. Untangling generic limits in *Azorella, Laretia,* and *Mulinum* (Apiaceae: Azorelloideae): Insights from phylogenetics and biogeography. Taxon: 61: 826-840.

----- and -----. 2014. Diversification times and biogeographic patterns in Apiales. Botanical Review 80: 30-58.

Nie, Z.-L., H. Sun, H. Li, and J. Wen, 2006. Intercontinental biogeography of subfamily Orontioideae (*Symplocarpus, Lysichiton,* and *Orontium*) of Araceae in eastern Asia and North America. Molecular Phylogenetics and Evolution 40: 155-165.

Nixon, K. C. and W. L. Crepet. 1989. *Trigonobalanus* (Fagaceae): Taxonomic status and phylogenetic relationships. American Journal of Botany 76: 828-841.

Nores, M. J., B. B. Simpson, P. Hick, A. M. Anton, and R. H. Fortunato. 2012. The phylogenetic relationships of four monospecific caesalpinioids, (Leguminosae) endemic to southern South America. Taxon 61: 790-802.

Norton, N. J. and J. W. Hall. 1969. Palynology of the Upper Cretaceous and Lower Tertiary in the type locality of the Hell Creek Formation, Montana. Palaeontographica, Abt. B, 125: 1-64.

Nylinder, S., U. Swenson, C. Persson, S. B. Janssens, and B. Oxelman. 2012. A dated species-tree approach to the trans-Pacific disjunction of the genus *Jovellana* (Calceolariaceae, Lamiales). Taxon 61: 381-391.

Oliveira Bünger, M. de. et al. The evolutionary history of *Eugenia* sect. Phyllocalyx (Myrtaceae) corroborates historically stable areas in the southern Atlantic forests. Annals of Botany 118: 1209-1223.

Olmstead, R. G. 2013. Phylogeny and biogeography in Solanaceae, Verbenaceae and Bignoniaceae: A comparison of continental and intercontinental diversification patterns. Botanical Journal of the Linnean Society 171: 80-102.

Ornelas, J. F., E. Ruiz-Sánchez, and V. Sosa. 2010. Phylogeography of *Podocarpus matudae* (Podocarpaceae): Pre-Quaternary relicts in northern Mesoamerican cloud forests. Journal of Biogeography 37: 2384-2396.

Ortiz-Jaureguizar, E. and G. A. Cladera. 2006. Paleoenvironmental evolution of southern South America during the Cenozoic. Journal of Arid Environments 66: 498-532.

Palacios Chávez, R. and J. Rzedowski. 1993. Estudio palinologíco de las flores fosiles del Mioceno inferior y principios del Mioceno medio de la region de Pichucalco, Chiapas, Mexico. Acta Botanica Mexicana 24: 1-96.

Palamarev, E. and D. H. Mai. 1998. Die palaeogenen Fagaceae in Europe: Artenvielfalt and Leitnien iher Entrwicklungsgeschichte. Acta Palaeobotanica 38: 227-299.

Palazzesi, L., V. Barreda, and M. C. Tellería. 2009. Fossil pollen grains of Asteraceae from the Miocene of Patagonia: Barnadesioideae affinity. Review of Paleobotany and Palynology 155: 83-88.

Pares Regali, M. de S., N. Uesugui, and A. d. S. Santos. 1974. Palynológia dos sedimentos Meso-Cenozóicos do Brasil (I, II). Boletim Técnico Petrobrás 17: 177-301.

Passalia, M. G., G. Del Fueyo, and S. Archangelsky. 2010. An Early Cretaceous

zamiaceous cycad of south west Gondwana: *Restrepophyllum* nov. gen. from Patagonia, Argentina. Review of Palaeobotany and Palynology 161: 137-150.

Paterson, A. H. et al. (+ 73 authors). 2012. Repeated polyploidization of *Gossypium* genomes and the evolution of spinnable cotton fibres. Nature 492: 423-427.

Pazzaglia, F. J., R. A. J. Robinson, and A. Traverse. 1997. Palynology of the Bryn Mawr Formation (Miocene): Insights on the age and genesis of Middle Atlantic margin fluvial deposits. Sedimentary Geology 108: 19-44.

Pedersen, K. R. 1976. Fossil floras of Greeneland. Geology of Greenland 1976: 519-538.

Pedersen, K. R., E. M. Friis, P. R. Crane, and A. N. Drinnan. 1994. Reproductive structures of an extinct platanoid from the Early Cretaceous (latest Albian) of eastern North America. Review of Palaeobotany and Palynology 80: 291-303.

Pérez-Consuegra, N. et al. 2015. Evolutionary history of fumitories (subfamily Fumarioideae, Papaveraceae): an old story shaped by the main geological and climatic events in the Northern Hemisphere. Molecular Phylogenetics and Evolution 88: 75-92.

----- et al. 2018. New records of Humiriaceae fossil fruits from the Oligocene and early Miocene of the western Azuero Peninsula, Panama. Boletin de la Sociedad Geológica Mexicana 70: 223-239.

Perret, M., A. Chautems, A. Onofre de Araujo, and N. Salamin. 2013. Temporal and spatial origin of Gesneriaceae in the New World inferred from plastid DNA sequences. Botanical Journal of the Linnean Society 171: 61-79.

Pigg, K. B. and M. L. DeVore. 2003. Paleocene fruits with affinities to Actinidiaceae from the Almont and Beicegel Creek floras of North Dakota. Abstract, Botany 2003,

July 26-31, Mobile, Alabama..

----- and -----. 2005. *Shirleya grahamae* gen. et sp. nov. (Lythraceae), *Lagerstroemia*-like fruits from the middle Miocene Yakima Canyon flora, central Washington State, USA. American Journal of Botany 92: 242-251.

----- and -----. 2005. *Paleoactaea* gen. nov. (Ranunculaceae) fruits from the Paleogene of North Dakota and the London Clay. American Journal of Botany 92: 1650-1659.

----- and -----. 2010. Floristic composition and variation in late Paleocene to early Eocene floras in North America. Bulletin of Geosciences 85: 135-154.

-----, -----, J. C. Benedict, and R. M. Creekmore. 2014. Fruits of *Melia* (Meliaceae) from the middle Miocene Yakima Canyon flora of central Washington State, U.S.A. In: W. D. Stevens, O. M. Montiel, and P. H. Raven (eds.), Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th year. Missouri Botanical Garden Press, St. Louis. Pp. 326-337.

-----, -----, and M. A. Brewer. 2005. Late Paleocene fruits similar to *Ochna* (Ochnaceae) from the Almont/Beicegel Creek floras, North Dakota, USA. Abstract, Botany 2005, August, Austin, Texas.

-----, -----, and K. E. Volkman. 2011. Fossil plants from Republic: A Guidebook. Stonerose Interpretive Center, Republic Washington.

-----, -----, and M. F. Wojciechowski. 2008. *Paleosecuridaca curtisii* gen. et sp. nov., *Securidaca*-like samaras (Polygalaceae) from the late Paleocene of North Dakota, USA and their significance to the divergence of families within the Fabales. International Journal of Plant Sciences 169: 1304-1313.

-----, -----, and W. C. Wehr. 2006. Filician ferns from the Tertiary of western North

America: *Osmunda* L. (Osmundaceae: Pteridophyta), *Woodwardia* Sm. (Blechnaceae: Pteridophyta), and onocleoid ferns (Filicales: Pteridophyta). Fern Gazette 17: 279-286.

-----, R. M. Dillhoff, M. L. DeVore, and W. C. Wehr. 2007. New diversity among the Trochodendraceae from the early/middle Eocene Okanogan Highlands of British Columbia, Canada, and northeastern Washington State, United States. International Journal of Plant Sciences 168: 521-532.

-----, S. R. Manchester, and M. L. DeVore. 2008. Fruits of Icacinaceae from the late Paleocene of western North America. American Journal of Botany 95: 824-832.

-----, -----, and W. C. Wehr. 2003. *Corylus, Carpinus* and *Paleocarpinus* (Betulaceae) from the middle Eocene Klondike Mountain and Allenby Formations of northwestern North America. International Journal of Plant Sciences 164: 807-822.

-----and G. W. Rothwell. 2001. Anatomically preserved *Woodwardia virginica* (Blechnaceae) and a new filicalean fern from the middle Miocene Yakima Canyon flora of central Washington, USA. American Journal of Botany 88: 777-787.

-----, R. A. Stockey, and S. L. Maxwell. 1993. *Paleomyrtinaea princetonensis* gen. et sp. nov., permineralized myrtaceous fruits and seeds from the Princeton Chert and related Myrtaceae from Almont, North Dakota. Canadian Journal of Botany 71: 1-9.

----- and W. C. Wehr. 2002. Tertiary flowers, fruits, and seeds of Washington State and adjacent areas. Washington Geology 30: 3-16.

-----, W. C. Wehr, and S. M. Ickert-Bond. 2001. *Trochodendron* and *Nordenskioldia* (Trochodendraceae) from the middle Eocene of Washington State, U.S.A. International Journal of Plant Sciences 162: 1187-1198.

Pingen, M., D. K. Ferguson, and M. E. Collinson. 1994. *Homalanthus costatus* Mai: A

new Miocene fruit of *Cinnamomum* Schaeffer (Lauraceae). Palaeontographica, Abt. B, 232: 155-174.

Pittermann, J., S. A. Stuart, T. E. Dawson, and A. Moreau. 2012. Cenozoic climate change shaped the evolutionary ecophysiology of the Cupressaceae conifers. Proceedings of the National Academy of Sciences USA 109: 9647-9652.

Pocknall, D. T. and D. M. Jarzen. 2009. Pollen with viscin threads from the Late Cretaceous and Paleocene, Mérida Andes, western Venezuela. Palynology 33: 55-61.

----- and -----. 2012. *Grimsdalea magnaclavata* Germeraad, Hopping & Muller: An enigmatic pollen type from the Neogene of northern South America. Palynology 36: 134-143.

Poinar, G., Jr. 2002. Fossil palm flowers in Dominican and Mexican amber. Botanical Journal of the Linnean Society 138: 57-61.

-----. 2016. The first fossil flower of Bignoniaceae (Lamiales): *Catalpa hispaniolae* sp. nov. in Dominican Republic amber. Novon 25: 57-63.

----- and L. Struwe. 2016. An astrid flower from neotropical mid-Tertiary amber. Nature Plants, www.nature.com natureplants, doi 10.1038/nplants.2016.5

Pons, D. and D. de Franceschi. 2007. Neogene woods from western Peruvian Amazon and Palaeoenvironmental interpretation. Bulletin of Geosciences (Czech Geological Survey, Prague) 82: 343-354.

Poole, I., D. Cantrill, and T. Utescher. 2005. A multi-proxy approach to determine Antarctic terrestrial palaeoclimate during the Late Cretaceous and Early Tertiary. Palaeogeography, Palaeoclimatology, Palaeoecology 222: 95-121.

-----, R. J. Hunt, and D. J. Cantrill. 2001. A fossil wood flora from King George Island:

ecological implications for an Antarctic Eocene vegetation. Annals of Botany 88: 33-54.

Prakash, V., M. B. Bande, and V. Lilatha. 1986. The genus *Phyllanthus* from the Tertiarty of India with critical remarks on the nomenclature of fossil woods of the Euphorbiaceae. Palaeobotanist 35: 106-114.

Prasad, V., C. A. E. Strömberg, H. Alimohammadian, and A. Sahni. 2005. Dinosaur coprolites and the early evolution of grasses and grazers. Science 310: 1177-1180.

-----, -----, A. D. Leaché, B. Samant, R. Patnaik, L. Tang, D. M. Mohabey, S. Ge, and A. Sahni. 2011. Late Cretaceous origin of the rice tribe provides evidence for early diversification in Poaceae. Nature Communications 2:480, DOI: 10:1038/ncomms 1482; www.nature.com/naturecommunications.

Pryer, K. M. 1999. Phyloeny of Marsileaceous ferns and relationships of the fossil *Hydropteris pinnata* reconsidered. International journal of Plant Sciences 160: 931-954.

Puebla, G. G., M. B. Prámparo, and M. A. Gandolfo. 2014. Aquatic ferns from the Upper Cretaceous Loncoche Formation, Mendoza, central-western, Argentina. Plant Systematics and Evolution, DOI: 10.1007/s00606-014-1096-7.

Punt, W. P. P. Hoen, S. Blackmore, S. Nilsson, and A. Le Thomas. 2007. Glossary of pollen and spore terminology. Review of Palaeobotany and Palynology 143: 1-81.

Quattrocchio, M. E., M. A. Martínez, M. A. Asensio, M. Elina Cornou, and D. E. Olivera. 2012. Palynology of El Foyel Group (Paleogene), Ñirihuau Basin, Argentina. Revista Brasileira de Paleontologia 15: 67-84.

-----, -----, L. P. Hinojosa, and C. Jaramillo. 2013. Quantitative analysis of Cenozoic

palynofloras from Patagonia, southern South America. Palynology 37: 246-258.

Quental, T. B. and C. R. Marshall. 2010. Diversity dynacims: Molecular phylogenies need the fossil record. Trends in Ecology & Evolution 25: 434-441.

Rabosky, D. L. 2009. Heritability of extinction rates links diversification patterns in molecular phylogenies and fossils. Systematic Biology 64: 1816-1824.

-----. 2010. Extinction rates should not be estimated from molecular phylogenies. Evolution 64: 1816-1824.

Radtke, M. G., K. B. Pigg, and W. C. Wehr. 2005. Fossil *Corylopsis* and *Fothergilla* leaves (Hamamelidaceae) from the lower Eocene flora of Republic, Washington, U.S.A., and their evolutionary and biogeographic significance. International Journal of Plant Sciences 166: 347-356.

Ramírez-Arriaga, E. M. B. Prámparo, A. F. Nieto-Samaniego, E. Martínez-Hernádes, A. Valiente-Banuet, C. Macías-Romo, and O. G. Dávalos-Alvarez. 2014. Palynological evidence for middle Miocene vegetation in the Tehuacán Formation of Puebla, Mexico. Palynology 38: 1-27.

Ramírez, J. L. and S. R. S. Cevallos-Ferriz. 2000. Leaves of Berberidaceae (*Berberis* and *Mahonia*) from Oligocene sediments near Tepexi de Rodríguez, Puebla. Review of Palaeobotany and Palynology 110: 247-257.

-----, S. R. S. Cevallos-Ferris, and A. Silva-Pineda. 2000. Reconstruction of the leaves of two species of *Pseudosmodingium* (Anacardiaceae) from Oligocene strata of Puebla, Mexico. International Journal of Plant Sciences 161: 509-519.

Ramírez, S. R., B. Gravendeel, R. B. Singer, C. R. Marshall, and N. E. Pierce. 2007. Dating the origin of the Orchidaceae from a fossil orchid with its pollinator. Nature

448: 1042-1045.

Rankin, B. D., R. A. Stockey, and G. Beard. 2008. Fruits of Icacinaceae from the Eocene Appian Way locality of Vancouver Island, British Columbia. International Journal of Plant Sciences 169: 305-314.

Raven, P. H. and D. I. Axelrod. 1974. Angiosperm biogeography and past continental movements. Annals of the Missouri Botanical Garden 61: 539-673.

Reid, E. M. and M. E. J. Chandler. 1933 et seq. The London Clay Flora. British Museum (Natural History), London.

Reinink-Smith, L. and E. B. Leopold. 2005. Warm climate in the late Miocene of the south coast of Alaska and the occurrence of Podocarpaceae pollen. Palynology 29: 205-262.

Renner, S. S., G. Clausing, and K. Meyer. 2001. Historical biogeography of Melastomataceae: The roles of Tertriary migration and long-distance dispersal. American Journal of Botany 88: 1290-1300.

-----, G. W. Grimm, G. M. Schneeweiss, T. F. Stuessy, and R. E. Ricklefs. 2008. Rooting and dating maples (*Acer*) with an uncorrelated-rates molecular clock: Implications for North American/Asian disjunctions. Systematic Biology 57: 795-808.

----- and K. Meyer. 2001. Melastomeae come full circle: Biogeographic reconstruction and molecular clock dating. Evolution 55: 1315-1324.

Retallack, G. J. 2004. Late Miocene climate and life on land in Oregon within a context of Neogene global change. Palaeogeography, Palaeoclimatology, Palaeoecology 214: 97-123.

-----, E. A. Bestland, and T. J. Fremd (eds.). 2000. Eocene and Oligocene Paleosols of

Central Oregon. Geological Society of America Special Paper 344. Boulder, CO.

Richardson, J.-E, et al. 2004. Historical biogeography of two cosmopolitan families of flowering plants: Annonaceae and Rhamnaceae. Philosophical Transactions of the Royal Society B (Biological Sciences) 359: 1495-1508.

Riley, M. G. and R. A. Stockey. 2004. *Cardstonia tolmanii* gen. et sp. nov. (Limnocharitaceae) from the Upper Cretaceous of Alberta, Canada. International Journal of Plant Sciences 165: 897-916.

Rodrigues, A., S. Shaya, T. A. Dickinson, and S. Stefanovic. 2013. Morphometric analyses and taxonomic revision of the North American holoparasitic genus *Conopholis* (Orobanchaceae). Systematic Botany 38: 795-804.

Rodríguez-Reyes, O., H. Falcon-Lang, P. Gasson, M. Collinson, and C. Jaramillo. 2014. Fossil woods (Malvaceae) from the lower Miocene (early to mid-Burdigalian) part of the Cucaracha Formation of Panama (Central America) and their biogeographic implications. Review of Palaeobotany and Palynology 209: 11-34.

Rohwer, J. G. 1993. Lauraceae. In: K. Kubitzki (ed.), The Families and Genera of Vascular Plants. II. Flowering Plants: Dicotyledons, pp. 366-391. Springer, Berlin.

Roncal, J., F. Kahn, B. Millan. T. L. P. Couvreur, and J.-C. Pintaud. 2013. Cenozoic colonization and diversification patterns of tropical American palms: Evidence from *Astrocaryum* (Arecaceae). Botanical Journal of the Linnean Society 171: 120-139.

Rothwell, G. W. 1999. Fossils and ferns in the resolution of land plant phylogeny. Botanical Review 65: 188-218.

----- and R. A. Stockey. 1989. Fossil Ophioglossales in the Paleocene of western North America. American Journal of Botany 76: 637-644.

----- and -----. 1991. *Onoclea sensibilis* in the Paleocene of North America, a dramatic example of structural and ecological stasis. Review of Palaeobotany and Palynology 70: 113-124.

----- and -----. 2006. Combining characters of Pteridaceae and tree ferns: *Pterisorus radiata* gen. et sp. nov., a permineralized Lower Cretaceous filicalean with radial sori. International Journal of Plant Sciences 167: 695-701.

----- and -----. 2016. Phylogenetic diversification of early Cretaceous seed plants: the compound seed cone of *Doylea tetrahedrasperma.* American Journal of Botany103: 923-937.

Ruhfel, B. R., C. P. Bove, C. T. Philbrick, and C. C. Davis. 2016. Dispersal largely explains the Gondwanan distribution of the ancient tropical clusioid plant clade. American Journal of Botany 103: 1117-1128.

Rydin, C., B. Mohr, and E. M. Friis. 2003. *Cratonia cotyledon* gen. et sp. nov.: A unique Cretaceous seedling related to *Welwitschia.* Proceedings of the Royal Society of London, B (supplement), 270: 29-32.

-----, K. R. Pedersen, P. R. Crane, and E. M. Friis. 2006. Former diversity of *Ephedra* (Gnetales): Evidence from Early Cretaceous seeds from Portugal and North America. Annals of Botany 98: 123-140.

-----, -----, and E. M. Friis. 2004. On the evolutionary history of *Ephedra*: Cretaceous fossils and extant molecules. Proceedings of the National Academy of Sciences USA 101: 16571-16576.

Salard-Cheboldaeff, M. 1978. Sur la palynoflore Maestrichienne et Tertiaire du basin sédimentaire littoral du Cameroun. Pollen et Spores 20: 215-260.

Schneider, A. C. et al. 2016. Pleistocene radiation of the serpentine-adapted genus *Hesperolinon* and other divergence times in Linaceae (Malpighiales). American Journal of Botany 103: 221-232.

----- and G. Zizka. 2017. Phylogeny, taxonomy and biogeography of neotropical Quiinoideae (Ochnaceae s.l.). Taxon 66: 855-867.

Schorn, H. E. 1998. *Holodiscus lisii* (Rosaceae): A new species of ocean spray from the late Eocene Florissant Formation, Colorado, USA. PaleoBios 18: 21-24.

----- and W. C. Wehr. 1986. *Abies milleri*, sp. nov., from the middle Eocene Klondike Mountain Formation, Republic, Ferry County, Washington. Burke Museum Contributions in Anthropology and Natural History 1: 1-7.

----- and -----. 1996. The conifer flora from the Eocene uplands at Republic, Washington. Washington Geology 24: 22-24.

Scott, R. A. 1954. Fossil fruits and seeds from the Eocene Clarno Formation of Oregon. Palaeontographica, Abt. B, 96: 66-97.

Segal, R. 1966. Taxonomic study of the fossil species of the genus *Cryptantha* (Boraginaceae). The Southwestern Naturalist 11: 205-210.

Selmeier, A. 1983. *Carapoxylon ortenburgense* n. sp. (Meliaceae) aus dem untermiozänen Ortenburger Schotter von Rauscheröd (Niederbayen). Mitteilungen der Bayerischen Staatssamulung für Paleontologie und Historische Geologie 23: 95-117.

Serbet, R., B. Bomfleur, and G. W. Rothwell. 2013. *Cunninghamia taylorii* sp. nov., a structurally preserved cupressaceous conifer from the Upper Cretaceous (Campanian) Horseshoe Canyon Formation of western North America. International Journal of Plant Sciences 174: 471-488. [Special Issue, Thomas N. Taylor Diamond Jubilee,

Conceptual Advances in Fossil Plant Biology].

Serbet, R. and G. W. Rothwell. 1999. *Osmunda cinnamomea* (Osmundaceae) in the Upper Cretaceous of western North America: Additional evidence for exceptional species longevity among filicalean ferns. International Journal of Plant Sciences 160: 425-433.

----- and -----. 2006. Anatomically preserved ferns from the Late Cretaceous of western North America. II. Blechnaceae/Dryopteridaceae. International Journal of Plant Sciences 167: 703-709.

Seward, A. C. 1927. Cretaceous plant-bearing rocks of western Greenland. Philosophical Transactions of the Royal Society of London, B, Biological Sciences 215: 57-175.

Sigel, E. M.. M. D. Windham, C. H. Haufler, and K. M. Pryer. 2014. Phylogeny, divergence time estimates, and phylogeography of the diploid species of the *Polypodium vulgare* complex (Polypodiaceae). Systematic Botany 39: 1042-1055.

Simon, R., A. F. Fuentes, and D. M. Spooner. 2011. Biogeographic implications of the striking discovery of a 4,000 kilometer disjunct population of the wild potato *Solanum morelliforme* in South America. Systematic Botany 36: 1062-1067.

Simpson, B. B., J. A. Tate, and A. Weeks. 2005. The biogeography of *Hoffmannseggia* (Leguminosae, Caesalpinioideae, Caesalpiniieae): A tale of many travels. Journal of Biogeography 32: 15-27.

Sims, H. J., P. S. Herendeen, and P. R. Crane. 1998. New genus of fossil Fagaceae from the Santonian (Late Cretaceous) of central Georgia, U.S.A. International Journal of Plant Sciences 159: 391-404.

-----, -----, R. Lupia, R. A. Christopher, and P. R. Crane. 1999. Fossil flowers with Normapolles pollen from the Upper Cretaceous of southeastern North America. Review of Palaeobotany and Palynology 106: 131-151.

Smith, J. F., A. C. Stevens, E. J. Tepe, and C. Davidson. 2008. Placing the origin of two species-rich genera in the Late Cretaceous with later species divergence in the Tertiary: A phylogenetic, biogeographic and molecular dating analysis of *Piper* and *Peperomia* (Piperaceae). Plant Systematics and Evolution 275: 9-30.

Smith, S. Y., G. W. Rothwell, and R. A. Stockey. 2003. *Cyathea cranhamii* sp. nov. (Cyatheaceae), anatomically preserved tree fern sori from the Lower Cretaceous of Vancouver Island, British Columbia. American Journal of Botany 90: 755-760.

----- and R. A. Stockey. 2001. A new species of *Pityostrobus* from the Lower Cretaceous of California and its bearing on the evolution of Pinaceae. International Journal of Plant Sciences 162: 669-681.

----- and R. A. Stockey. 2002. Permineralized pine cones from the Cretaceous of Vancouver Island, British Columbia. International Journal of Plant Sciences 163: 185-196.

----- and -----. 2003. Aroid seeds from the middle Eocene Princeton Chert (*Keratosperma allenbyense*, Araceae): Comparisons with extant Lasioideae. International Journal of Plant Sciences 164: 239-250.

----- and -----. 2007. Establishing a fossil record for the perianthless Piperales: *Saururus tuckerae* sp. nov. (Sauraceae) from the middle Eocene Princeton Chert. American Journal of Botany 94: 1642-1657.

-----, -----, H. Nishida, and G. W. Rothwell. 2006. *Trawetsia princetonensis* gen. et sp.

nov. (Blechnaceae): A permineralized fern from the middle Eocene Princeton Chert. International Journal of Plant Sciences 167: 711-719.

Smith V et al. (+ 4 authors and The Expedition 364 Science Party). Palaeocene-Eocene miospores from the Chicxulub impact crater, Mexico. Part 1: spores and gymnosperm pollen. Palynology, doi: 10.1080/01916122.2019.1630860.

Sniderman, J. M. K., G. J. Jordan, and R. M. Cowling. 2013. Fossil evidence for a hyperdiverse sclerophyll flora under a non-Mediterranaen-type climate. Proceedings of the National Academy of Sciences USA 110: 3423-3428.

Soltis, D. E., A. B. Morris, J. S. Mclachlan, P. S. Manos, and P. S. Soltis. 2006. Comparative phylogeography of unglaciated eastern North America. Molecular Ecology 15: 4261-4293.

----- et al. (+ 7 authors). 2013. Phylogenetic relationships and character evolution analysis of Saxifragales using a supermatrix approach. American Journal of Botany 100: 916-929.

Song, Z.-C., W.-M. Wang, and F. Huang. 2004. Fossil pollen records of extant angiosperms in China. Botanical Review 70: 425-458.

Spackamn, W. 1948. A dicotyledonous wood found associated with the Idaho tempskyas. Annals of the Missouri Botanical Garden 35: 107-115.

Spicer, R. A., A. Ahlberg, A. B. Herman, S. P. Kelley, M. I. Raikevich, and P. M. Rees. 2002. Paleoenvironment and ecology of the Middle Cretaceous Grebenka flora of northeastern Asia. Palaeogeography, Palaeoclimatology, Palaeoecology 184: 65-105.

----- and A. B. Herman. 1996. *Nilssoniocladus* in the Cretaceous Arctic: new species and biological isights. Review of Palaeobotany and Palynology 92: 229-243.

----- and -----. 2001. The Albian- Cenomanian flora of the Kukpowruk River, western North Slope, Alaska: stratigraphy, palaeofloristics, and plant communities. Cretaceous Research 22: 1-40.

Stockey, R. A. 2006. The fossil record of basal monocots. Aliso 22: 91-106.

----- and P. R. Crane. 1983. In situ *Cercidiphyllum*-like seedlings from the Paleocene of Alberta, Canada. American Journal of Botany 70: 1564-1568.

-----, G. L. Hoffman, and G. W. Rothwell. 1997. The fossil monocot *Limnobiophyllum scutatum*: Resolving the phylogeny of Lemnaceae. American Journal of Botany 84: 355-368.

-----, -----, and M. J. Vavrek. 2014. Paleobotany and paleoecology of the Munce's Hill fossil locality near Red Deer, Alberta, Canada. In: W. D. Stevens, O. M. Montiel, and P. H. Raven (eds.), Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th year. Missouri Botanical Garden Press, St. Louis. Pp. 367-

-----, T. C. Lantz, and G. W. Rothwell. 2006b. *Speirseopteris orbiculata* gen. et sp. nov. (Thelypteridaceae), a derived fossil filicalean from the Paleocene of western North America. International Journal of Plant Sciences 167: 729-736.

-----, B. A. LePage, and K. B. Pigg. 1998. Permineralized fruits of *Diplopanax* (Cornaceae, Mastixioideae) from the middle Eocene Princeton Chert of British Columbia. Review of Palaeobotany and Palynology 103: 223-234.

-----, H. Nishida, and G. W. Rothwell. 1999. Permineralized ferns from the middle Eocene Princeton Chert. I. *Makotopteris princetonensis* gen. et sp. nov. (Athyriaceae). International Journal of Plant Sciences 160: 1047-1055.

----- and G. W. Rothwell. 1997. The aquatic angiosperm *Trapago angulata* from the

Upper Cretaceous (Maastrichtian) St. Mary River Formation of southern Alberta. International Journal of Plant Sciences 158: 83-94.

----- and -----. 2003. Anatomically preserved *Williamsonia* (Williamsoniaceae): Evidence for Bennettitalean reproduction in the Late Cretaceous of western North America. International Journal of Plant Sciences 164: 251-262.

----- and -----. 2004. Cretaceous tree ferns of western North America: *Rickwoodopteris hirsuta* gen. et sp. nov. (Cyatheaceae s.l.). Review of Palaeobotany and Palynology 132: 103-114.

-----, -----, and A. B. Falder. 2001. Diversity among taxodioid conifers: *Metasequoia foxii* sp. nov. from the Paleocene of central Alberta, Canada. International Journal of Plant Sciences 162: 221-234.

-----, -----, and K. R. Johnson. 2007. *Cobbania corrugate* gen. et comb. nov. (Araceae): A floating aquatic monocot from the Upper Cretaceous of western North America. American Journal of Botany 94: 609-624.

-----, -----, and S. A. Little. 2006a. Relationships among fossil and living Dipteridaceae: Anatomically preserved *Hausmannia* from the Lower Cretaceous of Vancouver Island. International Journal of Plant Sciences 167: 649-663.

----- and S. Y. Smith. 2000. A new species of *Millerocaulis* (Osmundaceae) from the Lower Cretaceous of California. International Journal of Plant Sciences 161: 159-166.

----- and N. J. P. Wiebe. 2008. Lower Cretaceous conifers from Apple Bay, Vancouver Island: *Picea*-like leaves, *Midoriphyllum piceoides* gen. et sp. nov. (Pinaceae). Botany 86: 649-657.

Strömberg, C. A. E. 2004. Using phytolith assemblages to reconstruct the origin and

spread of grass-dominated habitats in the Great Plains of North America during the late Eocene to early Miocene. Palaeogeography, Palaeoclimatology, Palaeoecology 207: 239-275.

Struwe, L. et al. (+ 6 authors). 2009. Evolutionary patterns in neotropical Helieae (Gentianaceae): Evidence from morphology, chloroplast and nuclear DNA sequences. Taxon 58: 479-499.

Stuchlik, L., A. Szyniewicz, M. Lancucka-Srodoniowa, and E. Zastawniak. 1990. Results of the hitherto palaeobotanical investigations of the Tertiary brown coal bed "Belchatów" (central Poland). Acta Palaeobotanica 30: 259-305. [In polish with English summary].

Stuessy, T. 2010. The rise of sunflowers. Science 329: 1605-1606.

Stull, G. W., F. Herrera, S. R. Manchester, C. Jaramillo, and B. H. Tiffney. 2012. Fruits of an "Old World" tribe (Phytocreneae; Icacinaceae) from the Paleogene of North and South America. Systematic Botany 37: 784-794.

-----, B. Roger Moore, and S. R. Manchester. 2011. Fruits of Icacinaceae from the Eocene of southeastern North America and their biogeographic implications. International Journal of Plant Sciences 172: 935-947.

Sun, G., D. Dilcher, S. Zheng, and Z. Zhou. 1998. In search of the first flower: A Jurassic angiosperm, *Archaefructus*, from northeast China. Science 282: 1692-1695. ["The age of the Yixian Formation from which the fossil [*A. liaoningensis*] was recovered has been much debated, but recent independent radiometric dating from several horizons in the Yixian Formation strongly suggests a mid-Early Cretaceous rather than Late Jurassic age…" Friis et al., 2006, p. 256].

-----, -----, -----, K. Nixon, and X. Wang. 2002. Archaefructaceae, a new basal angiosperm family. Science 296: 899-904.

-----, -----, Hongshan Wang, and Zhiduan Chen. 2011. A eudicot from the Early Cretaceous of China. Nature 471: 625-628.

----- and R. A. Stockey. 1992. A new species of *Palaeocarpinus* Crane based on infructescences, fruits, seeds, staminate cones and leaves from the Paleocene of Alberta, Canada. International Journal of Plant Sciences 153: 136-146.

Swenson, U. and R. S. Hill. 2001. Most parsimonious areagrams versus fossils: The case of *Nothofagus* (Nothofagaceae). Australian Journal of Botany 49: 367-376.

Sytsma, K. J., A. Litt, M. L. Zjhra, J. C. Pires, M. Nepokroeff, E. Conti, J. Walker, and P. G. Wilson. 2004. Clades, clocks, and continents: Historical and biogeographical analysis of Myrtaceae, Vochysiaceae, and relatives in the Southern Hemisphere. International Journal of Plant Sciences 165: S85-S105.

Takahashi, M., P. R. Crane, and H. Ando. 1999. *Esgueiria futabensis* sp. nov., a new angiosperm flower from the Upper Cretaceous (lower Coniacian) of northeastern Honshu, Japan. Paleontological Research 3: 81-87.

Takhtajan, A. 1974. Magnoliophyta Fossilia URSS. Nauka, Lenningrad.

Tanai, T. 1981. The revision of the so-called "*Cercidiphyllum"* leaves from the Paleocene of north Japan. Journal of the Faculty of Science, Hokkaido University, Series 4, 19: 451-484.

Taylor, W. 2007. *Cyclocarya* and its significance to the diversification of Juglandaceae. Abstract, Botany & Plant Biology 2007, Chicago, IL..

-----, M. L. DeVore, and K. B. Pigg. 2006. *Suisea newsalemae*, gen. et sp. nov.

(Nymphaeaceae): *Euryale*-like seeds from the late Paleocene Almont flora, North Dakota, USA. International Journal of Plant Sciences 167: 1271-1278.

Thanikaimoni, G. 1987. Mangrove palynology. Institut Français de Pondichéry 24: 1-100.

Thayn, G. F. and W. D. Tidwell. 1984. A review of the genus *Paraphyllanthoxylon*. Review of Palaeobotany and Palynology 43: 321-335.

-----, -----, and W. L. Stokes. 1983. Flora of the Lower Cretaceous Cedar Mountain Formation of Utah and Colorado. Part I. *Paraphyllanthoxylon utahense.* Great Basin Naturalist 43: 394-402.

Thomasson, J. R. 1977. Late Cenozoic grasses, borages and hackberries from southwestern Nebraska. Contributions to Geology, University of Wyoming 16: 39-43.

-----. 1979. Late Cenozoic grasses and other angiosperms from Kansas, Nebraska, and Colorado: Biostratigraphy and relationships to living taxa. Kansas Geological Survey Bulletin 128: 1-68.

Thulin, M., S. G. Razafimandimbison, P. Chafe, N. Heidari, A. Kool, and J. S. Shore. 2012. Phylogeny of the Turneraceae clade (Passifloraceae s.l.): Trans-Atlantic disjunctions and two new genera in Africa. Taxon 61: 308-323.

Tiffney, B. H. 1985. The Eocene North Atlantic land bridge: Its importance in Tertiary and modern phyytogeography of the Northern Hemisphere. Journal of the Arnold Arboretum 66: 243-273.

-----. 2008. Phylogeography, fossils, and Northern Hemisphere biogeography: The role of physiological uniformitarianism. Annals of the Missouri Botanical Garden 95: 135-143.

-----. and K. K. Haggard. 1996. Fruits of Mastixioideae (Cornaceae) from the Paleogene of western North America. Review of Palaeobotany and Palynology 92: 29-54.

----- and S. R. Manchester. 2001. The use of geological and paleontological evidence in evaluating plant phylogeographic hypotheses in the Northern Hemisphere Tertiary. International Journal of Plant Sciences 162: S3-S17.

-----, S. R. Manchester, and P. W. Fritsch. 2018. Two new species of *Symplocos* based on endocarps from the early Miocene Brandon Lignite of Vermont, USA. Acta Palaeobotanica 58: 185-198.

Tosolini, A,-M. P., D. J. Cantrill, and J. E. Francis. 2013. Paleocene flora from Seymour Island, Antarctica: revision of Dusén's (1908) angiosperm taxa. Alcheringa 37: 1-26.

Trénel, P., M. Gustafsson, W. J. Baker, C. B. Asmussen-Lange, J. Dransfield, and F. Borchsenius. 2007. Mid-Tertiary dispersal, not Gondwanan vicariance explains distribution patterns in the wax palm subfamily (Ceroxyloideae: Arecaceae). Molecular Phylogenetics and Evolution 45: 272-288.

Tripp, E. A. and L. A. McDade. 2014. A rich fossil record yields calibrated phylogeny for Acanthaceae (Lamiales) and evidence for marked biases in timing and directionality of intercontinental disjunctions. Systematic Botany 63: 660-684.

Trivett, M. L., R. A. Stockey, G. W. Rothwell, and G. Beard. 2006. *Paralygodium vancouverensis* sp. nov. (Schizaeaceae): Additional evidence for filicalean diversity in the Paleogene of North America. International Journal of Plant Sciences 167: 675-681.

Trovó, M., M. J. G. de Andrade, P. T. Sano, P. L. Ribeiro, and C. van den Berg. 2013. Molecular phylogenetics and biogeography of Neotropical Paepalanthoideae with emphasis on Brazilian *Paepalanthus* (Eriocaulaceae). Botanical Journal of the Linnean

Society 171: 225-243.

Underwood, J. C. and C. N. Miller, Jr. 1980. *Pinus buchananii*, a new species based on a petrified cone from the Oligocene of Washington. American Journal of Botany 67: 1132-1135.

Upchurch, G. R., Jr., P. R. Crane, and A. N. Drinnan. 1994. The megaflora from the Quantico locality (upper Albian), Lower Cretaceous Potomac Group of Virginia. Virginia Museum of Natural History, Memoir 4: 1-57.

----- and J. A. Wolfe. 1987. Mid-Cretaceous to Early Tertiary vegetation and climate: Evidence from fossil leaves and woods. In: E. M. Friis, W. G. Chaloner, and P. R. Crane (eds.), The Origins of Angiosperms and their Biological Consequences, pp. 75-105. Cambridge University Press, Cambridge.

van der Hammen, T. and T. A. Wijmstra. 1964. A palynological study on the Tertiary and Upper Cretaceous of British Guiana. Leidse Geologische Mededelingen 30: 183-241.

Vavrek, M. J., R. A. Stockey, and G. W. Rothwell. 2006. *Osmunda vancouverensis* sp. nov. (Osmundaceae), permineralized fertile frond segments from the Lower Cretaceous of British Columbia, Canada. International Journal of Plant Sciences 167: 631-637.

Vicent, M., J. M. Gabriel y Galán, and E. B. Sessa. 2017. Phylogenetics and historical biogeography of *Lomaridium* (Blechnaceae: Polypodiopsida). Taxon 66: 1304-1316.

Viljoen, J.-A., A. Muthama Muasya, R. L. Barrett, J. J. Bruhl, A. K. Gibbs, J. A. Slingbsy, K. L. Wilson, and G. A. Verboom. 2013. Radiation and repeated transoceanic dispersal of Schoeneae (Cyperaceae) through the Southern Hemisphere. American Journal of Botany 100: 2494-2508.

Villar de Seoane, L. and S. Archangelsky. 2008. Taxonomy and biostratigraphy of Cretaceous megaspores from Patagonia, Argentina. Cretaceous Research 29: 354-372.

Voshell, S. M., R. M. Baldini, R. Kumar, N. Tatalovich, and K. W. Hilu. 2011. Canary grass (*Phalaris*, Poaceae): Molecular phylogenetics, polyploidy and floret evolution. Taxon 60: 1306-1316.

Wang, Hengchang, M. J. Moore, P. S. Soltis, C. B. Bell, S. F. Brockington, R. Alexandre, C. B. Davis, M. Latvis, S. R. Manchester, and D. E. Soltis. 2009. Rosid radiation and the rapid rise of angiosperm-dominated forests. Proceedings of the National Academy of Sciences USA 106: 3853-3858.

Wang, Hongshan and D. L. Dilcher. 2006. Aquatic angiosperms from the Dakota Formation (Albian, Lower Cretaceous), Hoisington III locality, Knasas, USA. International Journal of Plant Sciences 167: 385-401.

Wang, W. et al. (+ 6 et al. authors). 2012. Minispermaceae and the diversification of tropical rainforests near the Cretaceous-Paleocene boundary. New Phytologist 195: 470-478.

Wang, Y.-H., D. K. Ferguson, G.-P. Feng, Y.-F. Wang, S. G. Zhilin, C.-S. Li, P.-T. Svetlana, J. Yang, and A. G. Ablaev. 2009. The phytogeography of the extinct angiosperm *Nordenskioeldia* (Trochodendraceae) and its response to climate changes. Palaeogeography, Palaeoclimatology, and Palaeoecology 280: 183-192.

Wanntorp, L., M. E. Dettmann, and D. M. Jarzen. 2004. Tracking the Mesozoic distribution of *Gunnera*: Comparison with the fossil pollen species *Tricolpites reticulatus* Cookson. Review of Palaeobotany and Palynology 132: 163-174.

Watt, A. D. 1982. Index of generic names of fossil plants, 1974-1978. U. S. Geological

Survey Bulletin 1517: 1-63.

Weeks, A., D. C. Daly, and B. B. Simpson. 2005. The phylogenetic history and biogeography of the frankincense and myrrh family (Burseraceae) based on nuclear and chloroplast sequence data. Molecular Phylogenetics and Evolution 35: 85-101.

Wefferling, K. M., S. B. Hoot, and S. S. Neves. 2013. Phylogeny and fruit evolution in Menispermaceae. American Journal of Botany 100: 883-905.

Wehr, W. C. and D. Q. Hopkins. 1994. The Eocene orchards and gardens of Republic, Washington. Washington Geology 22: 27-34.

----- and S. R. Manchester. 1996. Paleobotanical significance of Eocene flowers, fruits, and seeds from Republic, Washington. Washington Geology 24: 25-27.

Weigend, M., M. Gottschling, F. Selvi, and H. H. Hilger. 2010. Fossil and extant Western Hemisphere Boragineae, and the polyphyly of "Trigonotideae" Riedl (Boraginaceae: Boraginoideae). Systematic Botany 35: 409-419.

-----, F. Selvi, M. Gottschling, and H. H. Hilger. 2009. Marbleseeds are gromwells-systematics and evolution of *Lithospermum* L. s.l. (Boraginaceae tribe Lithospermae) based on molecular and morphological data. Molecular Phylogenetics and Evolution 52: 755-768.

Wen, J. 1999. Evolution of eastern Asian and eastern North American disjunct distributions in flowering plants. Annual Review of Ecology and Systematics 30: 421-455.

-----. 2011. Systematic and biogeography of *Aralia* L. (Araliaceae): Revision of *Aralia* sects. *Aralia, Humiles, Nanae,* and *Sciadodendron*. Contributions from the United States National Herbarium 57:1-172.

----- et al. 2008. Phylogenetic inferences in *Prunus* (Rosaceae) using chloroplast *ndh*F and nuclear ribosomal ITS sequences. Journal of Systematics and Evolution 46: 322-332.

----- and S. M. Ickert-Bond. 2009. Evolution of the Madrean-Tethyan disjunctions and the North and South American amphitropical disjunctions in plants. Journal of Systematics and Evolution 47: 331-348.

--- et al. 2010. Timing and modes of evolution of Eastern Asian-North American biogeographic disjunctions in seed plants. In M. Long, H. Gu, and Z. Zhau (eds.), Darwin's Heritage Today. Proceedings of the Darwin 200 Beijing International Conference 252-269. Higher Education Press, Beijing.

Wen, J., R. H. Ree, S. M. Ickert-Bond, Z. Nie, and V. Funk. 2013. Biogeography: Where do we go from here? Taxon 62: 912-927.

Westgate, J. W. and C. T. Gee. 1990. Paleoecology of a middle Eocene mangrove biota (vertebrates, plants, and invertebrates) from southwest Texas. Palaeogeography, Palaeoclimatology, Palaeoecology 78: 163-177.

Wheeler, E. F. 1991. Paleocene dicotyledonous trees from Big Bend National Park, Texas: Variability in wood types common in the Late Cretaceous and Early Tertiary, and ecological inferences American Journal of Botany 78: 658-671.

-----, M. Lee, and L. C. Matten. 1987. Dicotyledonous woods from the Upper Cretaceous of southern Illinois. Botanical Journal of the Linnean Society 95: 77-100.

-----and T. M. Lehman. 2005. Upper Cretaceous-Paleocene conifer woods from Big Bend National Park, Texas. Palaeogeography, Palaeoclimatology, Palaeoecology 226: 233-258.

-----, -----, and T. M. Gasson. 1994. *Javelinoxylon*, an Upper Cretaceous dicotyledonous tree from Big Bend National Park, Texas, with presumed malvalean affinities. American Journal of Botany 81: 703-710.

----- and S. R. Manchester. 2002. Woods of the Eocene Nut Beds flora. International Association of Wood Anatomists Journal (IAWA), Supplement 3: 1-188.

-----, R. G. Pearson, C. A. LaPasha, W. Hatley, and T. Zack. 1986. Computer-aided Wood Identification. An Enhanced Oxford/PRL Type Database. North Carolina Agricultural Research Service Bulletin 474, North Carolina State University, Raleigh.

Wilf, P. 2012. Rainforest conifers of Eocene Patagonia: Attached cones and foliage of the extant southeast Asian and Australasian genus *Dacrycarpus* (Podocarpaceae). American Journal of Botany 99: 1-23.

----- et al. 2015. Presentation and abstract: Early Eocene *Physalis* fruits from Patagonia turn back the clock on evolution of Solonaceae and inflated calyx syndrome. Botany 2015 conference, Edmonton, Alberta, Canada.

-----, M. R. Carvalho, M. A. Gandolfo, and N. R. Cúneo. 2017. Eocene lantern fruits from Gondwanan Patagonia and the early origins of Solonaceae. Science 355: 71-75.

-----, M. P. Donovan, N. R. Cúeno, and M. A. Gandolfo. 2017. The fossil flip-leaves (*Retrophyllum*, Podocarpaceae) of southern South America. American Journal of Botany 104: 1344-1369.

-----, K.C. Nixon, M. A. Gandolfo, and N. R. Cúneo. 2019. Eocene Fagaceae and Gondwana legacy in Asian rainforests. Science 364, eaaw5139 (2019), doi: 10.1126/science.aaw5139.

-----, D. W. Stevenson, and N. R. Cúneo/ 2016. The last Patagonian cycad, *Austrozamia*

stockeyi gen et sp. nov., early Eocene of Laguna del Hunco, Chubut, Argentina. Botany 94: 817-829.

Winterton, C., J. E. Richardson, M. Hollingsworth, A. Clark, N. Zamora, and R. T. Pennington. 2014. Historical biogeography of the neotropical legume genus *Dussia*: the Andes, the Panama Isthmus, and the Chocó. In: W. D. Stevens, O. M. Montiel, and P. H. Raven (eds.), Paleobotany and Biogeography, a Festschrift for Alan Graham in his 80th Year. Missouri Botanical Garden Press, St. Louis. Pp. 389-404.

Wojciechowski, M. F. 2013. The origin and phylogenetic relationships of the Californian chaparral 'paleoendemic' *Pickeringia* (Leguminosae). Systematic Botany 38: 132-142.

Wolfe, J. A. and T. Tanai. 1987. Systematics, phylogeny, and distribution of *Acer* in the Cenozoic of western North America. Journal of the Faculty of Science of Hokkaido University, IV, Geology and Mineralogy 22: 1-246.

----- and W. C. Wehr. 1987. Middle Eocene dicotyledonous plants from Republic, northeastern Washington. U. S. Geological Survey Bulletin 1597: 1-25.

Xi, Z. et al. (+ 10 authors). 2012. Phylogenomics and a posteriori data partitioning resolve the Cretaceous angiosperm radiation Malpighiales. Proceedings of the National Academy of Sciences USA 109: 17519-17524.

Xiang, Q.-Y., Y. Shui, and Z. Murrell. 2003. *Cornus eydena* (Corrnaceae), a new cornelian cherry from China: Notes on systematics and evolution. Systematic Botany 28: 757-764.

Ya Li, T. Smith, C.-J. Liu, N. Awasthi, J. Yang, Y.-F. Wang, and C.-S. Li. 2011. Endocarps of *Prunus* (Rosaceae: Prunoideae) from the early Eocene of Wutu,

Shandong Province, China. Taxon 60: 555-564.

Yang, Y., B.-Y Geng, D. L. Dilcher, Z.-D. Chen, and T. A. Lott. 2005. Morphology and affinities of an Early Cretaceous *Ephedra* (Ephedraceae) from China. American Journal of Botany 92: 231-241.

Yu, Y., AJ. Harris, and X.-J He. 2010. S-DIVA (statistical dispersal-vicariance analysis): A tool for inferring biogeographic histories. Molecular Phylogenetics and Evolution 56: 848-850.

Zamaloa, M. del C. , M. A. Gandolfo, C. C. González, E. J. Romero, N. R. Cúneo, and P. Wilf. 2006. Casuarinaceae from the Eocene of Patagonia, Argentina. International Journal of Plant Sciences 167: 1279-1289.

----- and E. J. Romero. 1990. Some spores and pollen from the Cullen Formation (upper Eocene to middle Oligocene), Tierra del Fuego, Argentina. Palynology 14: 123-133.

Zavada, M. S. and W. L. Crepet. 1981. Investigations of angiosperms from the middle Eocene of North America: Flowers of the Celtidoideae. American Journal of Botany 68: 924-933.

----- and S. E. de Villiers. 2000. Pollen of the Asteraceae from the Paleocene-Eocene of South Africa. Grana 39: 39-45.

Zetter, R., M. J. Farabee, K. B. Pigg, S. R. Manchester, M. L. DeVore, and M. D. Nowak. 2011. Palynoflora of the late Paleocene silicified shale at Almont, North Dakaota, USA. Palynology 35: 179-211.

Zhou, Z., C. Quan, and Y.-S. (Christopher) Liu. 2012. Tertiary *Ginkgo* ovulate organs with associated leaves from North Dakota, U.S.A., and their evolutionary significance. International Journal of Plant Sciences 173: 667-6 80.