

Background

Florissant Fossil Beds National Monument, Colorado, preserves one of the most diverse fossil assemblages in the world. More than 130 late Eocene fossil plant species, in the form of wood, leaves, seeds, fruits, flowers, and pollen, have been described from the Florissant Formation. The collections at the Monument are made up primarily of dicotyledonous angiosperm leaves preserved in paper shale (fig. 1). Definitive identification of these leaves is an ongoing process.

Florissant plant fossils have been described continually since excavations began in the 1870s. In 1953, Harry MacGinitie revised previous paleobotanical work and published a monograph¹ on the flora of the Florissant Formation. Various researchers have subsequently revised species from this work and described new species. Despite these efforts, there is no current searchable set of descriptions of the fossil leaves from Florissant, making identification of the fossils difficult.

We constructed a database in Microsoft Access[™] 2010 containing descriptive information about all of the dicotyledonous leaves found at Florissant described as species or morphotypes. The database allows researchers to assign unknown Florissant fossil leaves to described morphotypes without having to search through previous literature and descriptions.

Methods

We compiled descriptions of the leaf morphotypes from several sources to maximize the potential variation in features within each morphotype included in the database. We included:

- The most recent published description of every morphotype. Published descriptions came primarily from MacGinitie (1953), but we also included earlier descriptions that were missing from the monograph and more recent descriptions of newly defined/classified types.
- Descriptions and diagrams made for a previous intern project at the monument.
- New descriptions we compiled based upon specimens from the Monument's collection and images from the Monument's online Museum Database² of published specimens.

The *Manual of Leaf Architecture*³ provided standardized terms and definitions for characters and characters states. Older descriptions were updated to standardize characters according to those defined in the *Manual*. For example, "... secondaries approaching close to margin, ascending and looping, simulating a marginal vein..." (MacGinitie p. 144) was recorded in the database as "brochidodromous secondary venation."

Characters were removed and additional characters were added in order to clearly distinguish among the leaf types. We also produced a guide for use of the database, including how to search the database and how to score leaf characters.

Leaf Attachment Leaf Organization Leaflet Arrangement Leaflet Number * Leaflet Attachment Petiole Features Laminar Attachment Laminar Shape Medial Symmetry Base Symmetry Lobation Margin Type Tooth Type **Special Margin Features** Apex Angle

List of characters used in the fossil leaf database

Apex Shape Base Angle Base Shape Primary Vein Framework Number of Basal Veins Major Secondary Framework Interior Secondaries Secondary Vein Branching* Agrophic Veins Minor Secondary Course Perimarginal Veins Major Secondary Spacing Variation of Secondary Angle Major Secondary Attachment **Basal Secondaries ***

Intersecondary Veins Intersecondary Proximal Course Intersecondary Length Intersecondary Distal Course Intersecondary Vein Frequency Intercostal Tertiary Veins Tooth Spacing Tooth Frequency * Number of Tooth Orders Sinus Shape Tooth Shape Principal Vein Termination Tooth Apex Features

Architecture

Building a fossil identification database for the leaves of Florissant Fossil Beds National Monument

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* characters not taken from the Manual of Leaf



Figure 1. A sample of dicotyledonous leaves from Florissant's collection showing the variety of features present in the flora. Top, left to right: Koelreuteria allenii, Populus crassa, Ribes errans, Paracarpinus fraterna, and Crataegus copeana. Bottom, left to right: Rhus lesquereuxi, Cedrelospermum lineatum, Rhus stellariaefolia or Sapindus coloradensis. Hydranaea fraxinifolia. and Caesalpinites coloradicus. Scale bars 0.5 cm.

												FLFO Species Scores						
2 Chack the matching character states in the drandown menu for each relevant character column in the database (helew)												E FLFO Species Scores						
S. CHECK IN	ematchin	y characte	er states mit	.ne dropdown menu	ior each	relevan	I CHAIACLEI	column in the	e ualabase (below	V).		Family	Fagaroao	Agrophic Veins	not present			
ELEO Species Scores												· anny	1080000		inv present	 Fagopsis longifolia 		
4 Fomily T	Conus	Choose	T Lominar Shanad	Anov Angla 🕅 Anov Shana 🔊	Basa Angla a	Baca Sl	Anno 🗖 Maior	Sacandan, Framawark	Major Cocondony Spacing	Major Socondon, Attachmo	nt Tooth Spacing T	Genus	Fagopsis	Major Secondary Framework	craspedodromous	•		
	Halasia	 Species 	✓ Laminar Snape ✓	Apex Angle Apex Shape	base Angle 🕈	Dase Si		Secondary Framework	 Major Secondary Spacing Image and an analysis 	 Major Secondary Attachment 	nt Tooth spacing	Species	longifolia	Interior Secondaries	not present	·		
Styracaceae	Halesia	reticulata	elliptic, ovate	acute convex, rounded, straight (cuneate)	acute 2 Z	Sort Ascendin	ing	aromous	irregular	decurrent, excurrent	not present	Leaf Attachment	petiolate	 Secondary Vein Branching 	not present	The section of t		
Rutaceae	Ptelea	cassiodes	elliptic, obovate,	acute, obtuse acuminate, convex,	acute	Clear filter fro	om Base Angle	dromous, odromous	irregular, regular	decurrent, excurrent	not present	Leaf Organization	not present	 Minor Secondary Course Perimarginal Veins 	not present	secondaries are dightly decurrent secondary veiro are straight		
Rosaceae	Rosa	hilliae	elliptic, ovate	acute obtuse convex rounded	acute obtus	(Select A	Ŋ	adromous	irregular	excurrent	regular	Leaflet Number	not present	Major Secondary Spacing	regular			
				truncate	acute, obtus	(Blanks)		spedodromous	niegulai	excurrent		Leaflet Attachment	not present	Variation of Secondary Angle	/ariation of Secondary Angle uniform			
Rosaceae	Amelanchier	scudderi	elliptic, obovate, ovate	acute, obtuse convex, rounded.	acute, obtus	acute		dromous.	irregular, regular	decurrent, excurrent	irregular, regular	Petiole Features	straight; no other features	Major Secondary Attachment	decurrent			
				straight (cuneate)		obtuse		mous,				Laminar Attachment	marginal	 Secondary Shape 	straight	base is generally symmetric		
Rosaceae	Cercocarpus	myricaefolius	elliptic, obovate,	acute, obtuse convex, rounded,	acute			odromous	gradually increasing	decurrent	regular	Laminar Shape	elliptic, oblong, ovate	 Basal Secondaries 	not present	Leaf attachment petiolate. Blade attachment marginal. Laminar shape elliptic with medial		
		,	ovate	straight (cuneate)					proximally, regular			Medial Symmetry	symmetrical	 Intersecondary Veins 	not present	symmetrical and base asymmetrical. Margin unlobed and toothed. Apex angle acute; apex shape convex; base angle obtuse; base shape convex. Primary venation plinnare; 1 basal velo. Major secondaries chapediodomoux; spacing regular, angle of attachment collows, structures does were there were interesting velocities were independent on the terminal collows.		
Rhamnaceae	Rhamnites	pseudo-	elliptic, obovate	acute, obtuse acuminate, convex,	acute			dromous,	irregular	excurrent	not present	Base Symmetry	asymmetrical, basal insertion asy	Intersecondary Proximal Course	e not present	regular, with 1 order of teeth; sinus shape angular. Tooth shape cvicy. Principal vein present; terminates at tooth apex.		
		stenophyllus		rounded				odromous				Lobation	unlobed	 Intersecondary Length 	not present			
Lauraceae	Lindera	coloradica	elliptic, obovate	acute, obtuse convex, rounded	acute, obtus	01	OK Cancel	dromous,	decreasing proximally and	excurrent	not present	Margin Type	toothed	 Intersecondary Distal Course 	not present	- alla		
							Cancer	odromous	distally, irregular			Special Margin Features	not present	Intersecondary Vein Frequency	not present			
Juglandaceae	Carya	libbeyi	elliptic, obovate, ovate	acute, obtuse acuminate, convex, rounded, straight	acute, obtuse	convex, rounded, crasped straight (cuneate) semicra		dodromous,	decreasing proximally,	excurrent	irregular	Tooth Type		Intercostal Tertiary Veins	mixed percurrent, percurrent			
								aspedodromous	irregular			Apex Angle	acute, obtuse	 Tooth Spacing 	regular			
Fagaceae	Fagopsis	longifolia	elliptic, oblong, ovate	acute, obtuse convex, rounded,	acute	convex, roun	ded, craspe	dodromous regular	decurrent	regular	Apex Shape	convex, rounded, straight (cunea	 Tooth Frequency 	single				
				straight (cuneate)		straight (cuneate)						Base Angle	acute	Number of Tooth Orders	1			
Anacardiaceae	Cotinus	fraterna	elliptic, obovate	acute convex, rounded,	acute	concave, convex, cladodr		omous,	irregular	decurrent	not present	Base Shape	convex, rounded, straight (cunea	Sinus Shape Tooth Shape	angular			
				straight (cuneate)		decurrent, rounded, semicra		aspedodromous				Number of Paral Voint	pinnate	Principal Vain Termination	et aces of teeth			
*												Number of basal vens	1	Tooth Apex Eestures	at apex or tooth			
												Other		Important Features	Fagonsis: biconvex teeth.			
														important reactores	regularly spaced secondaries, secondary venation attachment			
4. The data	base will f	ilter out al	I morphoty	pes that do not share	hose cl	haracter	· states, leav	/ing one or a	few candidate tv	vpes (below). The t	types can be				decurrent			
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verified by	comparing	g the unkr	nown leaf to	o images in the datab	ase spec	les form	IS (right), Or I	images from	the online Musel	um Database.						3920-B		
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FL	ELFO Species Scores														
	Family 🤜	च्र	Genus 🤜	 Species 	🗢 Laminar Shape∛	Apex Angle 🌮	Apex Shape	ኛ Base Angle ኛ	Base Shape	🛷 Major Secondary Framework 💞	Major Secondary Spacing 💞	Major Secondary Attachment 🗢	Tooth Spacing 🗢	Tooth Shape	æ.
Fag	gaceae	Fag	opsis	longifolia	elliptic, oblong,	acute, obtuse	convex, rounded,	acute	convex, rounded,	craspedodromous	regular	decurrent	regular	cv/cv, cv/fl, cv/st	
					ovate		straight (cuneate)		straight (cuneate)						

The Florissant fossil leaf identification database is a work-in-progress and will continue to change as more research is done on Florissant fossils and as more efficient ways to store and share this information are found. At present, the database has a number of limitations:

- be matched to a published morphotype.
- base.

Despite these limitations, this database is currently the most efficient way to identify dicotyledonous leaves from Florissant. It is the only source that combines all previous work on the leaves and therefore the only way to identify Florissant leaves without searching through numerous descriptions of published morphotypes in the previous literature.

Results

The database includes all 98 published dicotyledonous leaf morphotypes and 44 characters, 40 of which were taken directly from the Manual of Leaf Architecture. The others were added after we found that more characters were needed to distinguish between certain morphotypes.



How to use the database

1. Determine whether a fossil leaf is sufficiently well preserved to identify and note well preserved features (left).

- 2. Describe these features (right).
- leaf shape: elliptic
- apex angle: acute
- apex shape: convex
- base angle: acute
- base shape: straight
- secondary vein course: craspedodromous
- secondary vein spacing: regular
- tooth spacing: regular
- tooth shape: biconvex

Discussion

• Only well preserved leaves or leaves with especially distinctive features will be precisely matched to a morphotype. Only leaves that belong to published morphotypes will be accurately identified; leaves belonging to new morphotypes may be incorrectly assigned to published morphotypes. However, the database also has the capacity to recognize potentially new morphotypes when unknown leaves cannot

• The database is only available to researchers at Florissant Fossil Beds National Monument. • Microsoft AccessTM has limits on how many characters can be used, restricting the amount of detail and variation that can be included in the data-









secondary vein attachment to midvein: decurrent

References

- 1. MacGinitie, H.D. 1953. Fossil Plants of the Florissant beds, Colorado. Carnegie Institution of Washington Publication 599.
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