1 **Diverse early Paleocene megaflora from the Ojo Alamo Sandstone, San Juan Basin, New**
2 **Mexico, USA**

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Abstract.—Earliest Paleocene megafloras from North America are hypothesized to be low diversity and dominated by long-lived cosmopolitan species following the Cretaceous-Paleogene (K/Pg) mass extinction. However, megafloras used to develop this hypothesis are from the Northern Great Plains of North America, and relatively little is known about floras from southern basins.

Here, we present a quantitative analysis of a diverse earliest Paleocene megaflora (<350 kyr after K/Pg boundary) from the Ojo Alamo Sandstone in the San Juan Basin (SJB), New Mexico. The megaflora, comprised of 55 morphotypes, was dominated by dicotyledonous angiosperms, with accessory taxa composed of ferns, monocotyledonous angiosperms, and conifers. The majority of morphotypes were restricted to the SJB indicating the presence of an endemic flora in the earliest Paleocene. Diversity analyses indicate that the flora was species rich, highly uneven, and laterally heterogeneous. Paleoclimate estimates using multivariate and univariate methods indicate warm temperatures and high precipitation.

When compared to contemporaneous floras from the Denver Basin (DB) of Colorado and the Williston Basin (WB) of North Dakota, the SJB flora had significantly higher species richness, site rarefied richness, and basin rarefied richness, but was significantly less even. Paleoclimate estimates from the SJB were 7-14 °C warmer than the DB and WB, indicating a shift from a temperate deciduous forest biome in the Northern Great Plains to a tropical seasonal forest biome in the SJB. These results demonstrate that the SJB flora is markedly different from floras in the Northern Great Plains, that there were latitudinal differences in species composition and diversity, and that there was a variable floral response to the K/Pg boundary in North America during the earliest Paleocene. We hypothesize that the warm, wet conditions in the earliest

27 Paleocene SJB drove rapid rates of speciation following the K/Pg boundary resulting in a
28 heterogenous, endemic flora.

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33 **Introduction**

34 The Cretaceous-Paleogene (K/Pg) boundary at ~66 Ma is perhaps best known for the
35 extinction of non-avian dinosaurs (e.g., Schulte et al. 2010; Brusatte et al. 2015). However, there
36 was also a major extinction of plant taxa across the K/Pg boundary with ~50-60% and 15-30% of
37 mega- and microfloral species becoming extinct, respectively (e.g., Wilf and Johnson 2004;
38 Nichols and Johnson 2008; Vajda and Bercovici 2014). This floral extinction resulted in a major
39 restructuring of terrestrial ecosystems (e.g., McIver 1999; Wilf and Johnson 2004; Blonder et al.
40 2014) and a reduction in diversity in diversity that took millions of years to recover which
41 extended into the middle Paleocene (Hickey 1980; Wing et al. 1995; Dunn 2003; Wilf and
42 Johnson 2004; Peppe 2010). Thus, reconstructions of patterns of plant community diversity and
43 composition in the early Paleocene are necessary to fully understand both local and regional
44 ecosystem recovery following the K/Pg mass extinction.

45 Extensive early Paleocene megafloral collections have been made in North America for
46 almost 150 years (e.g., Newberry 1868; Lesquereux 1878; Brown 1962; Hickey 1980; Wolfe and
47 Upchurch 1987; Wing et al. 1995; Barclay et al. 2003; Peppe 2010). The majority of these
48 studies have focused on the northern Great Plains (NGP) of North America (Fig. 1A) (e.g.,
49 Newberry 1868; Lesquereux 1878; Brown 1962; Hickey 1980; Barclay et al. 2003; Dunn 2003;
50 Wilf and Johnson 2004; Peppe 2010), with large collections of earliest Paleocene floras from the
51 Denver Basin of central Colorado (Barclay et al. 2003; Johnson et al. 2003) and the Williston
52 Basin of North Dakota (e.g., Johnson 1989, 2002; Johnson and Hickey 1990; Wilf and Johnson
53 2004; Peppe 2010). Early Paleocene plant communities from the NGP are characterized by low
54 diversity and are dominated by long lived, cosmopolitan, mire adapted taxa (Hickey 1980;
55 Johnson 2002; Barclay et al. 2003; Peppe 2010). These floras were dominated by fast growing

angiosperms with high assimilation rates and low carbon investment, suggesting the K/Pg bolide impact selected against slower growing evergreen species leading to large scale ecosystem restructuring (Blonder et al. 2014). These patterns of low floral diversity and relatively homogeneous floral composition have been documented across a distance of >1200 km from southern Alberta to central Colorado (e.g., Brown 1962; Hickey 1980; McIver and Basinger 1993; Johnson 2002; Barclay et al. 2003; Dunn 2003; Peppe 2010). Analyses of NGP floras through the Paleocene indicate that it took several million years for floras to fully recover and approach levels of floral diversity common in the late Cretaceous (Hickey 1980; Wing et al. 1995; Dunn 2003; Wilf and Johnson 2004; Peppe 2010).

Although the early Paleocene flora of North America is commonly interpreted to have been relatively depauperate (e.g., Brown 1962; Hickey 1980; Peppe 2010), early Paleocene floras collected along the Colorado Front Range in the Denver Basin are considerably more diverse (Johnson and Ellis 2002; Ellis et al. 2003; Johnson et al. 2003). While contemporaneous floras from the Northern Great Plains had ~10-40 morphotypes (Hickey, 1980; Wing et al., 1995; Johnson, 2002; Dunn, 2003; Wilf and Johnson, 2004; Peppe, 2010), the floras from the Colorado Front Range typically have >30 morphotypes and have been used to suggest rapid floral recovery and high rates of speciation following the K/Pg boundary along the margins of the ancestral Rocky Mountains (Johnson and Ellis 2002; Ellis et al. 2003) . This pattern of recovery is in stark contrast to patterns of speciation and diversity documented across the Northern Great Plains, including floras from <50 km to the east in the central Denver Basin (e.g., Wing et al., 1995; Barclay et al., 2003; Johnson et al., 2003; Wilf and Johnson, 2004; Peppe, 2010). The majority of species found in the high diversity floras along the Colorado front range are endemic suggesting significant regional differences in floral diversity and composition across North America in the

early Paleocene (Johnson and Ellis 2002; Ellis et al. 2003). Additionally, Peppe (2010) hypothesized that early to mid-Paleocene climatic cooling impeded floral recovery in the Northern Great Plains, while the Denver Basin, being further south, was warmer and thus had more rapid recovery and diversification rates. However, little research has been done on the fossil floras from south of the Denver Basin making it difficult to test this hypothesis and inhibiting regional comparisons of floral diversity, composition, and recovery following the K/Pg boundary.

Here we describe a diverse early Paleocene fossil megafloa from the San Juan Basin of New Mexico that occurred within the first ~350 kyr of the Paleogene (Fig. 1, Fig. 2). We describe the composition and diversity of floral communities, examine differences in floral communities between depositional environments, and estimate mean annual temperature and precipitation within the San Juan Basin. Finally, we compare the earliest Paleocene San Juan Basin floras to contemporaneous floras from the Northern Great Plains of North America to assess regional differences in floral diversity, composition, and paleoclimate during the earliest Paleocene.

Geologic Setting

The San Juan Basin, located in northwestern New Mexico and southwestern Colorado (Fig. 1A), is a foreland basin formed during the Laramide Orogeny (Chapin and Cather 1983; Williamson 1996). The basin preserves a relatively continuous succession of terrestrial sedimentary rocks spanning the late Cretaceous (Campanian) through early Paleocene (Baltz et al. 1966; O'Sullivan et al. 1972; Williamson 1996; Williamson et al. 2008). Fossil plant material

for this study was collected from the earliest Paleocene Ojo Alamo Sandstone in the Bisti/De-Na-Zin (BDNZ) Wilderness Area (Fig. 1B-C). The Ojo Alamo Sandstone varies from 10-15 m in thickness in the study area and is a gold to yellow colored, cross bedded, medium to coarse grained sandstone with abundant siltstone lenses (Baltz et al. 1966; O'Sullivan et al. 1972). The Ojo Alamo Sandstone is thought to represent an alluvial plain with one or more sediment sources in the southern Rocky Mountains, which was deposited during the onset of tectonism associated with basin development (Powell 1973; Sikkink 1987). The Ojo Alamo Sandstone overlies the Maastrichtian Naashoibito Member of the Kirtland Formation and underlies the early Paleocene Nacimiento Formation (Baltz et al. 1966; Lindsay et al. 1978; Williamson 1996; Mason 2013; Peppe et al. 2013). The upper contact between the Ojo Alamo and Nacimiento is complex and regionally varies from being conformable with the basal paleosols of the Nacimiento weathering into the upper Ojo Alamo to unconformable with evidence for the contact being erosive (e.g., Williamson and Lucas 1992; Williamson 1996; Davis et al. 2016). In the BDNZ, the contact between the Ojo Alamo and Nacimiento appears to be conformable (Williamson 1996; Davis et al. 2016).

Differences in nomenclature between the Ojo Alamo Sandstone and the Naashoibito Member have caused confusion when relating the two lithologic units (e.g., Sullivan et al. 2005; Williamson and Weil 2008; Fassett 2009). The Ojo Alamo Sandstone and Naashoibito Member have both been recognized as unique stratigraphic units in different formations (e.g., Baltz et al. 1966; Williamson 1996; Williamson and Weil 2008; Williamson et al. 2008) or as different members within the Ojo Alamo Formation (e.g., Sullivan et al. 2005; Fassett 2009). For this study, we use the definition of Baltz (1966) for the Ojo Alamo Sandstone and recognize it as a

unique stratigraphic formation. For clarity, this is equivalent to the Kimbeto Member of the Ojo Alamo Formation proposed by Sullivan et al. (2005).

In addition to confusion about the nomenclature of the Ojo Alamo Sandstone and the Naashoibito Member, the age of the units remain contentious with some authors claiming both the Ojo Alamo and Naashoibito are Paleocene (Fassett 2009), while others contend that the Naashoibito is early Maastrichtian and the Ojo Alamo Sandstone is early Paleocene (Sullivan and Lucas 2003; Sullivan et al. 2005; Williamson et al. 2008). Palynostratigraphy of the Ojo Alamo Sandstone and the Nacimiento Formation indicates that the Ojo Alamo is earliest Paleocene (Anderson 1959; Williamson et al. 2008). Further, the occurrence of *Momipites inaequalis* in the Ojo Alamo Sandstone (Anderson 1959), suggests that it can be correlated to the North American Paleocene palynostratigraphic zones P1 or P2 (Nichols 2003). Recently, Mason (2013) used detrital sanidine dating to constrain the maximum depositional age of the Naashoibito Member to the late Maastrichtian and the Ojo Alamo Sandstone near Cuba, New Mexico to early Paleocene in age. Magnetostratigraphy from the BDNZ Wilderness Area through the Naashoibito, Ojo Alamo Sandstone, and lower Nacimiento formation indicate that the upper Naashoibito Member, the entire Ojo Alamo Sandstone, and the basal 4 m of the Nacimiento formation are all reversed polarity indicating that they were all deposited with magnetic chron 29r (Peppe et al. 2013). Based on the Ojo Alamo pollen assemblage and geochronology of the Naashoibito, Ojo Alamo, and Nacimiento, we interpret that the Ojo Alamo floras that are the focus of this work were all deposited within C29r during the first ~350 Kyr of the Paleocene (Fig. 2).

Methods

3.1 Collection and classification

Plant fossil were collected from 12 localities from the Ojo Alamo Sandstone in the BDNZ Wilderness Area during the 2013-2016 (Fig. 1C). Because the upper and lower contacts of the Ojo Alamo are not flat lying, the stratigraphic position of each leaf locality was measured to both the top of underlying Naashoibito Member of the Kirkland Formation and the overlying Nacimiento Formation. Localities ranged from 7.5 to 14.5 m above the base of the Ojo Alamo Sandstone and between 8.0 and 1.0 m below the Nacimiento Formation contact (Fig. 2). Localities were assigned a two letter code for site discoverer, and a field locality number using a two-digit annual number indicating the year of collection and a sequential site number (e.g. AF1404 is the fourth site found by Andrew Flynn in 2014). For census collections, a specimen number and site number was added to each sample. All collected specimens are currently stored at Baylor University.

Fossil leaf bearing deposits are common in the Ojo Alamo Sandstone and are typically either fine grained, thinly laminated carbonaceous shales, which are interpreted to represent pond or swamp facies (7 localities, 58% of sites), or interbedded fine-grained sandstones and siltstones, which are interpreted to represent overbank or crevasse splay facies (5 localities, 42% of sites). All samples were collected using the bench and quarry method where large blocks of matrix were split along leaf-bearing bedding planes (*sensu* Johnson 1989). Fossil leaf quarries generally covered ~5-10 m² of surface area and multiple, relatively thin (~5-25 cm) leaf bearing layers occurred at most leaf localities. At all leaf quarries, sedimentological features were recorded and sites were assigned to a sedimentary facies.

Fossil plant specimens were collected quantitatively (census collections) and selectively (voucher collections). During census collections, all identifiable specimens found in the field

were tallied and a representative sample(s) of each census morphotype was collected. At least 300 identifiable specimens were tallied in the field during census collections since modern taphonomic studies have shown that ≥ 300 specimens are needed to accurately reflect floral composition (Burnham et al. 1992). Voucher collections, where at least 1 specimen of each morphotype was collected, were made from leaf localities where collecting ≥ 300 identifiable specimens was not feasible.

All identifiable specimens were assigned to base-wide morphotypes. Morphotypes are distinct floral morphologies within a flora with no formal taxonomic assignment, but are presumed to represent biological species (for review of morphotyping method, see Ash et al. 1999; Peppe et al. 2008; Ellis et al. 2009). When possible, morphotypes were also assigned to previously described Linnaean taxa for comparison to previously published collections. The majority of morphotypes from the Ojo Alamo Sandstone represent apparently previously undescribed species and are presumed to represent endemic taxa. Dicotyledonous angiosperm morphotypes were described using the *Manual of Leaf Architecture* (Ellis et al. 2009). All other plant groups were described based on their morphology and distinctive traits. Descriptions and illustrations of all morphotypes are included in the supplementary materials and a systematic list of morphotypes with their taxonomy and species names is included in Supplementary Table 1.

3.2 Floral diversity

All diversity analysis was performed using the paleontological statistical program PAST 3.0 (Hammer et al. 2001). Rarefaction analyses was performed on the six megafloal census collections in the SJB and age equivalent sites (i.e., sites within magnetic polarity chron 29r) in

the Denver Basin (DB) of central Colorado (Barclay et al. 2003) and the Williston Basin (WB) of western North Dakota and eastern Montana (Wilf and Johnson 2004; Peppe 2010) using all collected taxa. Rarefaction analyses for only dicotyledonous angiosperm leaves were also conducted for the same localities within the SJB, DB, and WB with ≥ 200 dicotyledonous angiosperm samples. Total basin rarefaction analyses, in which all census data within each basin was combined, were also calculated for all plant groups and only dicotyledonous angiosperm leaves from the SJB, DB, and WB.

To assess differences in the relative evenness and overall distribution of morphotypes, several modern ecological diversity indices were calculated using all quantitatively collected localities from the SJB, DB, and WB. The Simpson's Index of Diversity (D) (Simpson 1949) was calculated to compare the diversity between SJB localities and compare SJB localities to DB and WB floras. Due to D decreasing as diversity increase, the reciprocal of the Simpson's Index ($1/D$) is expressed here to better illustrate the relationship between D and diversity (see Magurran 2004). The Simpson's Evenness Index ($E_{1/D}$) (Smith and Wilson 1996) was also calculated for all leaf localities to assess the relative distribution of morphotypes. Lastly, the Berger-Parker index (d) (Berger and Parker 1970) was calculated to quantify the dominance of the most abundant taxa for each site from the SJB and other contemporaneous floras.

Detrended correspondence analysis (DCA) was used to assess the influence of depositional facies (i.e. landscape position) on floral composition using the six census collections. Cluster analysis was also performed on the six census localities using the Raup-Crick similarity index (Raup and Crick 1979) to identify groupings of localities. Floral heterogeneity between sites (i.e. β -diversity) was analyzed using the Bray-Curtis distance index (Bray and

Curtis 1957) between all pairs of census localities. The total results, within facies, and between facies were then averaged to obtain total and facies specific values of floral heterogeneity.

3.3 Paleoclimate and paleoecology

Digital leaf physiognomy (DiLP) is a multivariate paleoclimate model which uses the size and shape of fossil leaves to estimate the mean annual temperature (MAT) and mean annual precipitation (MAP) (Huff et al. 2003; Royer et al. 2005; Peppe et al. 2011). All non-aquatic woody dicotyledonous angiosperm leaves with at least 25% of the leaf area and margin preserved were measured using the protocols of Peppe et al. (2011) and Royer et al. (2005). For morphotypes with < 25% of the leaf lamina preserved, only the presence or absence of teeth was scored (See Supp. Table 5-6 for DiLP measurements).

Leaf margin analysis (LMA) (Miller et al. 2006) and leaf area analysis (LAA) (Wilf et al. 1998) were used to estimate MAT and MAP respectively for the SJB, DB, and WB to facilitate regional paleoclimate comparisons. LMA is a univariate climate model that uses the presence or absence of toothed woody dicot angiosperm leaves to estimate MAT (Wilf 1997; Miller et al. 2006; Peppe et al. 2017). The SE for the LMA MAT estimate was calculated using uncertainty equation of Miller et al. (2006). LAA is a univariate climate model which uses the average leaf size of a flora to estimate MAP (Wilf et al. 1998; Peppe et al. 2017). Each morphotype was scored to a Raunkiaer-Webb leaf size class (Webb 1959) to estimate leaf area. Site mean leaf area was calculated using the methods of Wilf et al. (1998).

Leaf mass per area (M_a) is a proxy for leaf lifespan (Wright et al. 2004; Royer et al. 2007, 2010; Riva et al. 2016), and the M_a threshold between deciduous and evergreen taxa is ~129 g

m⁻² (Wright et al. 2004; Royer et al. 2007, 2010). The M_a of fossil leaves was estimated following the methods of Royer et al. (2007) using the relationship between petiole width (PW) and leaf area (A) to M_a.

Results

4.1 San Juan Basin floral description

Megafloral collections from the SJB yielded 55 morphotypes: 6 pteridophytes (10.91% of the morphotypes), 2 conifers (3.64%), 8 monocotyledonous (monocot) angiosperms (14.55%), and 39 dicotyledonous (dicot) angiosperms (70.91%) (Table 1). The 6 census collections produced 2941 specimens comprised of 5.57% pteridophytes, 3.26% conifers, 4.86% monocots, and 86.29% dicots (Table 1). The majority of the morphotypes have not been previously described (69.19%) and likely represent a taxa endemic to the SJB during the early Paleocene (Supplementary Table 1).

4.2 San Juan Basin floral diversity

The average rarefied richness from the six Ojo Alamo census localities was 13.49 ± 0.92 morphotypes (down sampled to 300 specimens per locality) (Fig. 2A). With the exception of site AF1402, the site rarefaction curves have not become asymptotic indicating that total species richness has likely not been sampled (Fig. 2A) (Foote 1992; Hammer et al. 2001). When only dicotyledonous angiosperm leaves were included in the rarefaction analysis, the average rarefied richness from the six census localities was 7.35 ± 0.70 morphotypes (down sampled to 200

specimens per locality) (Fig. 2B, Table 4). The total rarefied richness of the Ojo Alamo flora was 39.70 ± 2.17 morphotypes (down sampled to 1400 samples) (Fig. 5C, Table 4). The total basin-wide rarefied richness for only dicot leaves was 21.79 ± 1.90 morphotypes (down sampled to 900 specimens) (Fig. 5D).

There was a strong facies effect on floral composition and diversity within the SJB flora. The pond and overbank floras had 27 and 31 morphotypes, respectively (Table 2). The taxonomic composition of the floras is notably different as they only share 12 morphotypes. When including all plant groups, the overbank flora had a greater rarefied richness at 300 specimens (18.13 ± 0.56 morphotypes, $n = 2$) than the pond flora (11.17 ± 1.06 morphotypes, $n = 4$). A more pronounced pattern of difference in richness was evident when only including dicot angiosperm leaves, with the overbank flora having more than double the rarefied richness at 200 morphotypes (12.05 ± 0.75 morphotypes, $n = 2$) of the pond flora (5.00 ± 0.68 morphotypes, $n = 4$).

In addition to having higher species richness, the overbank flora had a greater $1/D$ value (pond flora: 2.21 ± 0.07 ; overbank flora: 5.21 ± 0.55) and $E_{1/D}$ value (pond flora: 0.158 ± 0.003 ; overbank flora: 0.308 ± 0.018) indicating the overbank flora was significantly more diverse and more even than the pond flora. Additionally, the Berger-Parker index for the pond flora was greater than the overbank flora (pond flora: 0.7745 ± 0.0171 ; overbank flora: 0.1850 ± 0.0121) indicating the pond flora was more heavily dominated by the most common morphotype.

Detrended correspondence analysis indicated that composition and relative abundance of morphotypes was considerably different between the pond and crevasse splay facies (Fig. 4a). Raup-Crick cluster analysis indicated two major clusters corresponding to the overbank and pond localities (Fig. 4b). In 10,000 runs, the clustering of overbank and pond localities into separate

groups occurred 100% of the time indicating the difference in floral composition between facies is significant. Cluster analysis also indicated that overbank localities were less similar to each other than the pond localities, with the two overbank localities having a 0.25 similarity index, while the pond 4 pond localities had a similarity index > 0.9 (Fig. 4b).

Bray-Curtis Index of Similarity distances were calculated to assess floral differences between facies using the morphotype occurrences and frequencies between the 6 census localities (Table 3). The overall mean Bray-Curtis distance between localities was 0.278 indicating considerable difference between the censused floras. The average Bray-Curtis distance between pond localities was 0.571 and between overbank localities was 0.396 indicating overbank localities are less similar to each other than pond localities. Additionally, the mean Bray-Curtis distance between facies was 0.154 and within facies was 0.588. These results are statistically significant ($t = 4.312$, $p = 0.008$, $df = 13$), indicating that the β -diversity between different facies was greater than within facies.

4.3 San Juan Basin paleoclimate and paleoecology

The estimated MAT using DiLP from the total Ojo Alamo Sandstone was 30.7 ± 4.0 °C ($n = 30$ morphotypes) and using LMA was 23.52 ± 2.46 °C ($n = 33$ morphotypes) (Table 4, Supplementary Table 5). The estimated MAP using DiLP for the Ojo Alamo sandstone was 153.8 cm/yr ($+123.6/-68.5$ cm/yr), $n = 30$ morphotypes) and using LAA was 215.9 cm/yr ($+93.2/-65.1$ cm/yr, $n = 33$ morphotypes) (Table 4). DiLP is likely underestimating MAP since large fossil leaves are often fragmentary and impossible to include in DiLP analysis (see discussion in Peppe et al., 2017).

To assess the effect of facies on paleoclimate estimates, the DiLP MAT and MAP was calculated separately for the overbank and pond floras. The two different data sets used to calculate these estimates had very little overlap in their morphotype composition (Supplementary Table 6), yet their paleoclimate estimates were nearly identical. The MAT estimated using DiLP for the pond flora was 26.1 ± 4.0 °C and 25.8 ± 4.0 °C for the overbank flora (Table 4, Supplementary Table 6). The MAP estimated using DiLP for the pond flora was 144.4 cm/yr (+116.1/-64.4 cm/yr) and 168.5 cm/yr (+135.4/-75.1 cm/yr) for the overbank flora (Table 4, Supplementary Table 5). These results indicate that despite differences in the taxonomic composition, there is no facies effect with respect to MAT and MAP estimates.

The M_a estimates for the total Ojo Alamo Sandstone was 84.77 g/m^2 (+143.84/-53.33 g/m^2 , $n = 11$ morphotypes; Table 4), and only one morphotype had a LMA greater than 129 g/m^2 (Table 4), indicating that the majority of Ojo Alamo morphotypes had a LL < 12 months and were deciduous (Royer et al. 2007). When the MAT and MAP are plotted with relation to modern ecosystems (Whittaker 1975), the SJB flora corresponds with a tropical seasonal forest (Fig. 6). Tropical seasonal forests are often dominated by deciduous taxa (e.g. Whittaker 1975; Yoshifuji et al. 2006), which is similar to our M_a and LL estimates for the Ojo Alamo flora..

4.4 Regional Floral Diversity and Paleoclimate -

The SJB flora had greater species richness ($n = 55$ morphotypes) than contemporaneous floras from the DB ($n = 25$ morphotypes, Barclay et al. 2003) and the WB ($n = 33$ morphotypes, Wilf and Johnson 2004; $n = 24$ morphotypes, Peppe 2010) (Table 5). The mean site rarefied richness at 300 specimens from the SJB (13.79 ± 0.93) was greater than the DB (11.65 ± 0.62 ,

Barclay et al. 2003) and the WB (8.75 ± 0.77 , Wilf and Johnson 2004; 11.81 ± 0.67 , Peppe 2010) indicating greater α -diversity in the SJB than floras from the Northern Great Plains (Fig. 5A, Table 5). The basin wide rarefied richness at 1400 specimens was also greater in the SJB (40.79 ± 2.28) than the DB (24.41 ± 0.73 , Barclay et al. 2003) and the WB (25.37 ± 1.70 , Wilf and Johnson 2004; 23.96 ± 0.20 , Peppe 2010) (Table 5, Fig. 5C). The difference in both site and basin-wide rarefied richness is smaller when using only dicot angiosperm leaves (Fig. 5B-D), because compared to the DB and WB a greater proportion of the SJB flora is composed of non-dicot angiosperm morphotypes.

The Simpson's $1/D$ and $E_{1/D}$ indices for the SJB flora (2.47 ± 0.86 , 0.049 ± 0.017) are lower than the DB (6.49 ± 0.17 , 0.260 ± 0.007 ; Barclay et al. 2003) and the WB (5.93 ± 0.89 , 0.180 ± 0.027 ; Wilf and Johnson 2004; 7.23 ± 0.71 , 0.301 ± 0.030 ; Peppe 2010) indicating the SJB flora is significantly less even than floras from the Northern Great Plains (Table 5). Additionally, the SJB flora is more heavily dominated by the most common morphotype ($d = 0.6267$) compared to the DB ($d = 0.2332$, Barclay et al. 2003) and WB ($d = 0.3119$, Wilf and Johnson 2004; $d = 0.2154$, Peppe 2010) (Table 5).

The paleoclimate estimates using LMA indicate the SJB ($24.34^\circ\text{C} \pm 2.33^\circ\text{C}$) was warmer than the DB ($17.89^\circ\text{C} \pm 2.90^\circ\text{C}$; Barclay et al. 2003) and the WB ($10.24^\circ\text{C} \pm 3.95^\circ\text{C}$; Peppe 2010) (Table 6). The estimated MAP using LAA from the SJB (215.9 cm/yr , $+93.2/-65.1\text{ cm/yr}$) is wetter than the DB (155.0 cm/yr , $+66.9/-46.8\text{ cm/yr}$; Barclay et al. 2003) and the WB (154.4 cm/yr , $+66.7/-46.6\text{ cm/yr}$; Peppe 2010) (Table 6).

Discussion

5.1 San Juan Basin flora

The early Paleocene SJB flora is dominated by dicot angiosperms both in number of morphotypes and number of specimens (Table 1). Pteridophytes, conifers, and monocot angiosperms are accessory taxa (29.09% of morphotypes and 13.69% of specimens; Table 1), but are common at some localities (Supplementary Table 2). The SJB flora has high species richness (55 morphotypes), but relatively high dominance (Table 5) indicating a species rich, but uneven flora.

There is a strong facies effect on the Ojo Alamo floral composition and diversity. Interestingly, this pattern has not identified in contemporaneous floras from western North America. Additionally, while the pond floras are relatively homogeneous, there is a large difference in species composition between the overbank floras indicating a considerable variability in floral composition within the higher disturbance overbank facies (Fig. 4). Only 12 morphotypes (21.82%) are found in both the pond and overbank facies. The majority of the shared morphotypes, such as *Platanites raynoldsii* and *Averrhoites affinis*, have widespread distribution throughout the Western Interior of North America during the early Paleocene (e.g., Johnson 2002; Barclay et al. 2003; Dunn 2003; Peppe 2010). Conversely, the majority of facies restricted morphotypes are endemic to the SJB.

The pond flora is more strongly dominated by non-dicot morphotypes than the overbank facies, as indicated by the large difference in dicotyledonous angiosperm rarefied richness between overbank and pond floras (Fig. 3B). The modern nearest living relatives of the majority of these morphotypes, such as ferns and cupressaceous conifers (i.e. *Onoclea sensibilis* (SJ-56) and *Cupressinocladus interruptis* (SJ-68)), are commonly found in water saturated environments (Mehltreter et al. 2010; Pittermann et al. 2012), supporting our interpretation that these deposits

represent ponds and/or swamps. The modern relatives of common overbank morphotypes, such as *Platanites marginata* (SJ-71) and *Browneia serrata* (SJ-78), are frequently found near lake and stream-side habitats (Stromberg 2001; Manchester and Hickey 2007) supporting our interpretation that these deposits represent the banks and floodplains of a braided stream.

The strong facies effect on diversity is possibly explained by taphonomic differences or lateral heterogeneity in the floral communities between the pond and overbank facies environments. If taphonomy caused the observed facies effect, we would expect the overbank facies to have higher species richness than the pond facies due to a larger catchment area “collecting” multiple depositional environments (Ellis and Johnson 2013). Additionally, we would expect that because the overbank facies incorporated morphotypes from other facies, paleoclimate estimates between facies might differ because of the incorporation of allochthonous morphotypes. However, while the overbank facies did have higher species richness than the pond facies (Table 2), the two facies shared relatively few morphotypes, suggesting that the overbank facies did not sample taxa from the pond facies. Additionally, the overbank localities were more dissimilar to each other than the pond localities (Table 3), which suggests considerable variability in the floral composition between overbank facies localities and between the pond and overbank facies. Finally, DiLP paleoclimate estimates for the two facies were nearly identical, which suggests both facies are sampling the *in situ* flora (Table 4). Based on the differences in floral composition between the pond and overbank facies and the similar paleoclimate estimates, it is highly unlikely that the facies effect that we document is the result of differences in taphonomy.

If lateral heterogeneity caused the observed facies effect, we would expect that the different depositional facies would have different floral compositions and diversity, but produce

similar paleoclimate estimates. This pattern best fits our observed data with the two facies having little compositional overlap, but producing the same paleoclimate estimates (Table 2-4). Thus, we interpret the documented facies effect to be the result of significant heterogeneity in the Ojo Alamo plant communities. We interpret the observed facies effect, and high lateral variability in plant communities to be explained by the intermediate disturbance hypothesis (IDH), which predicts the highest species diversity occurs in areas of intermediate disturbance (Connell 1978). In tropical forest communities, disturbance creates holes in the canopy allowing a succession of plant species to colonize the newly available growing area leading to greater species richness (e.g., Brokaw and Busing 2000; Molino 2001). The overbank flora was deposited in more active parts of the depositional system, and thus underwent more disturbance which resulted in greater floral diversity. The modern relatives of common SJB overbank flora species (such as *P. raynoldsii*) are commonly pioneer species (Stromberg 2001) supporting our hypothesis that these localities underwent episodic disturbance. The lower diversity pond flora was deposited in a restricted and less active area of the depositional system which encountered relatively little disturbance, which may have allowed a few species (i.e. *A. affinis*) to become dominant. The effect of disturbance on diversity is also highlighted by the pond flora being significantly less even and more dominated by a single morphotype when compared to the overbank flora (Table 2).

5.2 Regional floral comparison

5.2.1 Regional patterns of floral diversity.—The SJB flora has ~40-55% higher species richness than contemporaneous floras from North America (Table 5). The SJB flora also has ~15-20% higher rarefied richness at the site level and ~35-40% higher rarefied richness at the

basin-wide level (Table 5). The increased relative difference in rarefied richness at the basin-wide level is driven by the large amount of lateral heterogeneity in the SJB not found elsewhere in the Northern Great Plains and the predominance of non-dicot angiosperm taxa (Fig. 3). However, while the SJB flora was more species rich, it was significantly less even and more strongly dominated by common morphotypes than contemporaneous Northern Great Plains floras (Table 5). While the most common taxa make up between 21.54 - 33.19% of samples from the DB and WB, the most common taxa in the SJB makes up 62.67% of samples collected (Table 5). The high richness, but uneven flora runs counter to the hypothesis that the earliest Paleocene floras have low species richness and were relatively even (e.g., Hickey 1980; Johnson and Ellis 2002; Barclay et al. 2003; Wilf and Johnson 2004). This suggests that there were different responses to the K/Pg extinction event across North America, and potentially the rapid development of a latitudinal gradient in diversity in the early Paleocene.

These results demonstrating higher species richness in the SJB compared to the Northern Great Plains also runs counter to the hypothesis that due to the closer proximity to the K/Pg bolide impact in the Yucatan Peninsula (Alvarez et al. 1980; Hildebrand et al. 1991), extinction rates among plants would be higher in southern North America, resulting in lower diversity floras (Wolfe and Upchurch 1986). Greater floral diversity in the SJB within 350 kyr of the K/Pg boundary in the SJB relative to the Northern Great Plains could be the result of: (1) lower extinction rates in the SJB compared to the Northern Great Plains, (2) significantly higher floral diversity in the SJB in Maastrichtian compared to contemporaneous floras from the Northern Great Plains, or (3) higher rates of speciation in the SJB in the early Paleocene compared to the Northern Great Plains. Given the proximity to the bolide impact a lower extinction rate of plants in the SJB seems the least likely scenario. However, the youngest Cretaceous fossil leaf record in

the SJB is from the Campanian (e.g., Davies-Vollum et al. 2011), and no Maastrichtian leaf localities have been found. This makes it impossible to determine rates of extinction or latest Cretaceous floral diversity in the SJB. Assuming a similar rate of extinction in the SJB to the WB (~50%), it is possible that the difference in diversity between the SJB and the DB and WB (~40-55% higher in the SJB) is the result of higher diversity during the Maastrichtian. Alternatively, if extinction rates were higher in the SJB than in the DB and WB, which seems likely because the SJB is considerably closer to the K/Pg impact site in the Yucatan Peninsula than the DB and the WB, higher temperature and precipitation could have helped drive faster rates of speciation in the SJB than in the Northern Great Plains or created favorable condition to allow taxa to disperse into the SJB from regional refugia. In this scenario, recovery following the K/Pg boundary in the SJB would have been was more rapid than in other parts of North America. We favor the scenario that speciation and/or dispersal rates were faster in the SJB than in other parts of the Northern Great Plains as a result of more favorable climatic conditions, but acknowledge that fossil material from the Maastrichtian is required to test this hypothesis.

Early Paleocene fossil floras from Patagonia also have relatively high species richness (Iglesias et al. 2007; Comer et al. 2015), which has been linked to lower rates of extinction and dispersal of refugia taxa following the K/Pg boundary (Donovan et al. 2016). The early Paleocene megaflora from the Salamanca Formation in Argentina (64.67-63.49 Ma) had >50% more species than comparable North American localities (Iglesias et al. 2007), but similar levels of species richness to the SJB Ojo Alamo flora. This suggests that the pattern in macrofloral diversity found in the SJB could be more similar to South American floras than floras from the Northern Great Plains in North America, but further work will need to be done to test this hypothesis.

460
461 5.2.2 *Regional patterns in floral composition.*—The megafloral composition of the Ojo
462 Alamo flora is significantly different than previously studied locations in the Western Interior of
463 North America. Many of the SJB morphotypes appear to represent previously unpublished,
464 endemic taxa (Table S1). Out of 55 morphotypes, 20 (37.74 %) have been identified in other
465 early Paleocene basins, with only 17 (30.91 %) having previously published taxonomic names
466 (Table S1). The SJB flora has 17 morphotypes (30.91 %) in common with the Denver Basin
467 (Barclay et al. 2003; Ellis et al. 2003; Johnson et al. 2003) and 13 morphotypes (24.53 %) in
468 common with the Williston Basin (Wilf and Johnson 2004; Peppe 2010). The 35 morphotypes
469 endemic to the SJB make up the majority of floral species richness, and thus are driving the
470 higher species richness in the SJB.

471 Research on early Paleocene floras from North America has suggested that they are
472 relatively similar across North America (e.g., Brown, 1962; Johnson, 2002; Johnson et al., 2003;
473 Barclay et al., 2003; Peppe, 2010) and are dominated by diagnostic “FU1 taxa” (*sensu* Johnson
474 and Hickey 1990; Johnson 2002). In the San Juan Basin, the “FU1 taxa” *P. raynoldsii*, *Browneia*
475 *serrata* (SJ-78), “*Populus*” *nebrascensis* (SJ-13) and *Paranymphea crassifolia* (SJ-51) are
476 present. However, the majority of “FU1 taxa” such as the dicot angiosperms *Quereuxia*
477 *angulata*, *Mciveraephyllum nebrascense*, *Zizophoides flabella* and the taxodiaceous conifers
478 *Glyptostrobus europaeus* and *Metasequoia occidentalis* are absent. Further, with the exception of
479 *P. raynoldsii*, the “FU1 taxa” present in the SJB are rare, while accessory taxa in the Northern
480 Great Plains, that are not typical “FU1 taxa”, such as *Averrhoites affinis* and *Ditaxocladus*
481 *catenulatus* (SJ-102), are common in the SJB. *Ginkgo adiantoides* and *M. occidentalis* are also
482 common in the Northern Great Plains (Johnson 2002; Peppe 2010), but are notably absent from

the SJB flora. The SJB was likely too warm for *G. adiantoides* and *M. occidentalis* since their nearest living relatives are restricted to temperate climates in latitudes above ~35 °N (Tralau 1967; Ziegler et al. 1996; Liu et al. 2007). While “FU1 taxa” are rare, the Ojo Alamo flora does share a number of morphotypes with floras in the DB and WB, and thus these occurrences extend the geographic range of 18 previously described taxa ~350 km further south. The taxonomic comparison between the Ojo Alamo SJB floras and floras from the Northern Great Plains demonstrate that the composition of the Ojo Alamo SJB floras was considerably different from contemporaneous floras in North America during the early Paleocene (Johnson and Hickey 1990; Johnson 2002; Barclay et al. 2003; Wilf and Johnson 2004; Peppe 2010). Given the significant differences between the Ojo Alamo flora and floras from the Northern Great Plains, our results suggest that the earliest Paleocene San Juan Basin flora was dominated by endemic taxa. This flora was probably derived from endemic Cretaceous taxa in the SJB, speciation following the K-Pg boundary, and/or taxa dispersing into the basin from other parts of North and Central America in the earliest Paleocene.

5.2.3 Regional patterns of facies effect on floral composition.—The strong facies effect on floral composition and diversity document here in the SJB has not been previously identified in contemporaneous early Paleocene floras from the Northern Great Plains (e.g., Barclay et al. 2003; Peppe 2010). Hickey (1980) documented a facies effect from the middle Paleocene of the Clark’s Fork Basin in Wyoming, with channel margin deposits tending to be the most diverse localities, whereas conifer dominated back swamp deposits were less diverse and more homogenous. Our results from the SJB are very similar, and floras collected from the better-drained levees near channels are higher diversity and composed of a more heterogeneous dicot

community than the homogenous, lower diversity floras occurring in the poorly-drained lowlands and near oxbow lakes. However, unlike the Clark's Fork basin, ferns and monocots dominate the low-lying pond deposits instead of conifers (Fig. 3A, Supplementary Table 2). This likely reflects the higher temperatures in the SJB, which excluded the dominant conifer taxa that occurred in the Clark's Fork Basin in the middle Paleocene (Tralau 1967; Hickey 1980; Liu et al. 2007). Importantly, the facies effects found in the SJB mirrors modern fluvial systems with the highest diversity in the better drained, levee type overbank areas and the lowest diversity in the poorly-drained lowland areas (Frye and Quinn 1979).

It is possible that taphonomic differences could explain the differences in diversity and species richness between the SJB and the DB and WB. However, similar facies were sampled in the DB (Barclay et al. 2003) and WB (Peppe 2010) with no appreciable facies effect. Thus, we interpret the differences in diversity and species richness between basins as reflecting true differences in floral composition and diversity. Further, given that previous studies have not found a facies effect in plant composition, we argue that the facies effects found in the SJB indicates that there was greater lateral heterogeneity in plant community composition in the SJB than in floras in other parts of the Northern Great Plains.

5.3 Early Paleocene paleoclimate

Mean annual temperature for the SJB using DiLP ($27.4^{\circ}\text{C} \pm 4.0^{\circ}\text{C}$) is significantly higher than the DiLP MAT estimate from the WB ($15.7^{\circ}\text{C} \pm 4.0^{\circ}\text{C}$; Peppe et al. 2011). The estimated MAT using LMA from the SJB ($24.16^{\circ}\text{C} \pm 2.33^{\circ}\text{C}$) was also higher than the estimated MAT from the DB ($17.89^{\circ}\text{C} \pm 2.90^{\circ}\text{C}$, Barclay et al. 2003) and the WB ($10.24^{\circ}\text{C} \pm$

3.95 °C, Peppe et al. 2011) (Table 5). The large difference in MAT between DiLP and LMA is probably related to the freshwater margin effect where toothed leaves are more common in environments with seasonal water availability because leaf teeth allow for more rapid leaf growth (Peppe et al. 2011), which can cause LMA to underestimate MAT.

The DiLP estimated MAP for the SJB (153.8 cm/yr +123.6/-68.5 cm/yr) is lower than the DiLP estimated MAP from the WB (175.0 cm/yr +144.0/-79.0 cm/yr; Peppe et al. 2011). However, the estimated MAP using LAA from the SJB (183.8 cm/yr +79.4/-55.4 cm/yr) was greater than the DB (155.0 cm/yr +66.9/-46.8 cm/yr; Barclay et al. 2003) and the WB (154.4 cm/yr +66.7/-46.6 cm/yr; Peppe et al. 2011) (Table 6). DiLP is likely underestimating MAP for the SJB because many SJB morphotypes are large, entire margined, and known only from fragmentary remains. When the average leaf size estimated from LAA is used in DiLP, the MAP increases to 213.6 cm/yr (+171.7/-95.2 cm/yr), which is similar to the LAA estimates and probably represents a more realistic estimate of MAP.

These results indicate the climate in the SJB was warmer and wetter than previously studied locations in western North America. Additionally, when the MAT and MAP of each basin is compared to modern ecosystems (Whittaker 1975), the climate of the SJB flora is most similar to a tropical seasonal forest biome while the DB and WB climate indicates a temperate deciduous forest biome (Fig. 7). In modern ecosystems, tropical seasonal and tropical dry forests have higher alpha diversity than temperate deciduous forests (Spurr and Barnes 1980), which is similar to our analyses which indicate greater site species richness in the SJB. In tropical forest ecosystems, the degree of deciduousness in the plant communities is controlled by the amount of precipitation and the length and magnitude of the dry season (Condit et al. 2000; Pyke et al. 2001). The M_a estimates from the Ojo Alamo flora indicate that the majority of measurable

species were deciduous. Modern tropical forests dominated by deciduous species are marked by a long dry season with no precipitation and a short but intense wet season (Bullock and Solis-Magallanes 1990). The Ojo Alamo Sandstone has been interpreted to represent a braided stream system on an alluvial plain subject to seasonal precipitation (Powell 1973; Fassett 1985; Sikkink 1987). Taken together, this indicates that precipitation was during the deposition of the Ojo Alamo was most likely seasonal with a significant dry season. Today tropical seasonal forests are restricted to ~20 °N/S of the equator (Spurr and Barnes 1980). However, the paleolatitude of the SJB was 41.65 °N (reconstructed based on Torsvik et al. 2008), which indicates a considerable northward expansion of tropical biomes during the earliest Paleocene.

Conclusion

The Ojo Alamo Sandstone fossil leaf record documents the occurrence of a diverse megafloa in the San Juan Basin within 350 kyr of the Cretaceous-Paleogene boundary. The SJB floa is dominated by dicot angiosperms with pteridophytes, conifers, and monocot angiosperms as common accessory taxa. There is a strong facies effect on floral diversity and composition in the SJB: (1) an overbank floa found on riparian margins which has higher species richness, is more even, and was dominated by fast-growing pioneer dicot angiosperms species and (2) a pond floa found in swamps or low-lying areas which has lower species richness, is less even, and non-dicot angiosperm morphotypes were more common. The majority of morphotypes found in the SJB floa have not been previously described indicating a large proportion of endemic taxa in the floa. Paleoclimate estimates from the SJB indicate a very warm and wet climate consistent with a modern tropical seasonal forest biome.

When compared to contemporaneous floras from North America, the SJB flora has ~40-55% greater species richness, but is significantly less even. While taxa common in the Northern Great Plains are present in the SJB flora, only *P. raynoldsii* is common, whereas accessory taxa in the Northern Great Plains are important parts of the SJB flora. The strong facies effect on diversity and composition found in the SJB has not previously been identified in North America. The pattern of laterally heterogeneous, species rich, but uneven flora found in the SJB runs counter to the paradigm of the earliest Paleocene floras in North America being relatively low diversity and dominated by a few long-lived taxa (e.g., Johnson and Hickey 1990; Johnson 2002; Peppe 2010). Additionally, the SJB paleoclimate estimates indicate a much warmer and slightly wetter environment than previously studied localities further north (Barclay et al. 2003; Peppe 2010). Taken together these results demonstrate that the early Paleocene flora in the SJB is markedly different from floras in the Northern Great Plains and there were significant differences in species composition and diversity along a north-south gradient in North America in the earliest Paleocene. We hypothesize that the warm, wet conditions in the SJB drove rapid rates of speciation following the K/Pg boundary resulting in a heterogeneous, endemic flora in the earliest Paleocene. These results indicate that the floral response to the K/Pg boundary was variable regionally across North America and that there may have been climatically driven latitudinal effect, such as the northward expansion of the tropical seasonal forest biome that influenced these regional patterns.

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867

Tables

Table 1 – Number of morphotypes and specimens by major taxonomic category and organ type.
For detailed taxonomic information see Supplementary Table 1; for full morphotype descriptions see Appendix 1.

Higher taxon or organ	Morphotypes	Specimens	% Morphotypes	% Specimens
Pteridophytes				
Leaves	5	163	9.09	5.54
Reproductive structures	1	1	1.82	0.03
Conifers	2	96	3.64	3.26
Monocotyledonous angiosperms				
Leaves	7	142	12.73	4.83
Reproductive structures	1	1	1.82	0.03
Dicotyledonous angiosperms				
Leaves	35	2533	63.64	86.12
Reproductive structures	4	5	7.27	0.17
Total	55	2941		

887 Table 2 – Comparison of total # of morphotypes, # of specimens, Simpson’s Index of Diversity,
 888 Simpson’s Evenness, and Berger-Parker Dominance for each floral facies and total flora. The
 889 pond flora had fewer morphotypes, lower diversity and evenness compared to the overbank flora.
 890 Additionally, the pond flora was more strongly dominated by the most common morphotype.

<i>Facies</i>	<i># of Morphotypes</i>	<i># of Specimens</i>	<i>Simpson’s Diversity Index (1/D)</i>	<i>Simpson’s Evenness ($E_{1/D}$)</i>	<i>Berger-Parker Dominance (d)</i>
<i>Total</i>	55	2941	2.47 ± 0.86	0.049 ± 0.017	0.6267 ± 0.0177
<i>Pond</i>	28	2275	2.21 ± 0.07	0.158 ± 0.003	0.7745 ± 0.0171
<i>Overbank</i>	32	666	5.21 ± 0.55	0.308 ± 0.018	0.1850 ± 0.0121

891

892

893 Table 3 - Bray-Curtis Index of Similarity: Beta Diversity Proxy. Mean distance – 0.278. Within
 894 facies (0.588) is greater than between facies (0.154) and is statistically significant ($t = 4.312$, $df =$
 895 13, $p = 0.0008$). Average between pond localities (0.571) is greater than average between
 896 overbank localities (0.396) indicating pond facies had more similar floral composition.

	DP1301/01B	AF1402	AF1404	AF1407	AF1407B	AF1409D
DP1301/01B	---					
AF1402	0.788	---				
AF1404	0.090	0.069	---			
AF1407	0.883	0.721	0.081	---		
AF1407B	0.350	0.366	0.292	0.316	---	
AF1409D	0.158	0.126	0.396	0.133	0.279	---

897

898 Table 4 – SJB paleoclimate estimates using digital leaf physiognomy (DiLP) (Peppe et al. 2011),
 899 leaf margin analysis (LMA) (Miller et al. 2006), leaf area analysis (LAA) (Wilf et al. 1998), and
 900 leaf mass per area (M_a) (Royer et al. 2007) for the total flora and each floral facies.

<i>Site/Facies</i>	<i>DiLP MAT (°C)</i>	<i>LMA MAT (°C)</i>	<i>DiLP MAP (cm/yr)</i>	<i>LAA MAP (cm/yr)</i>	<i>M_a (g/m²)</i>
<i>Total Ojo Alamo</i>	27.4 ± 4.0	24.34 ± 2.27	154.4 +126.9/-69.6	215.9 +93.2/-65.1	78.1 +113.9/-55.2
<i>Pond Flora</i>	23.6 ± 4.0	24.51 ± 2.79	156.3 +128.5/-70.5	142.3 +61.5/-42.9	74.5 +107.5/-51.6
<i>Overbank Flora</i>	27.3 ± 4.0	22.40 ± 3.04	174.3 +143.3/-78.6	234.4 +101.2/-70.7	79.3 +113.4/-55.5

901

902 Table 5 – Comparison of diversity measurements for San Juan Basin, Denver Basin, and
 903 Williston Basin. Error indicates 95% confidence interval.

<i>Diversity Measurement</i>	<i>San Juan Basin (this study)</i>	<i>Denver Basin (Barclay et al. 2003)</i>	<i>Williston Basin (Wilf and Johnson 2004)</i>	<i>Williston Basin (Peppe 2010)</i>
<i>Species Richness</i>	55	25	33	24
<i>Average Site Rarefaction @300 Specimens</i>	13.79 ± 0.93	11.65 ± 0.62	8.75 ± 0.77	11.81 ± 0.67
<i>Total Basin Rarefaction @1400 Specimens</i>	40.79 ± 2.28	24.41 ± 0.73	25.37 ± 1.70	23.96 ± 0.20
<i>Simpson's Index ($1/D$)</i>	2.47 ± 0.86	6.49 ± 0.17	5.93 ± 0.89	7.23 ± 0.71
<i>Simpson's Evenness ($E_{1/D}$)</i>	0.049 ± 0.017	0.260 ± 0.007	0.180 ± 0.027	0.301 ± 0.030
<i>Berger-Parker Index (d)</i>	0.6267	0.2332	0.3119	0.2154

904

905 Table 6 – Comparison of SJB, DB, and WB MAT estimates using LMA (Miller et al. 2006) and
 906 MAP using LAA (Wilf et al. 1998). Error indicates 95% confidence interval.

<i>Basin</i>	<i>MAT (°C)</i>	<i>MAP (cm/yr)</i>
<i>San Juan</i>	24.34 ± 2.33	215.9 +93.2/-65.1
<i>Denver</i>	17.89 ± 2.90	155.0 +66.9/-46.8
<i>Williston</i>	10.24 ± 3.95	154.4 +66.7/-46.6

907

908

Figure Captions

Figure 1 – Location map of the San Juan Basin and study location. A: Early Paleocene basins of North America modified from Peppe 2010, B: Geologic map of the southwestern San Juan Basin showing the geographic occurrences of late Cretaceous – Eocene deposits; modified from Williamson et al. 2008, C: Geologic map of the Bisti/De-Na-Zin Wilderness area with fossil leaf sites indicated. Filled shapes = census collections, open shapes = voucher collections

Figure 2 – Geochronology of the late Cretaceous Naashoibito Member and the early Paleocene Ojo Alamo Sandstone and Nacimiento. Age interpretations based on Mason (2013) and Peppe et al. (2013). North American Land Mammal Age (NALMA) and biozone (Pu1, Pu2) from Williamson (1996). The stratigraphic position of all floras shown relative to the Ojo Alamo/Naashoibito contact. Leaf localities: grey = census, open = voucher

Figure 3 – Rarefaction curves for early Paleocene Ojo Alamo Sandstone floral; grey shaded areas indicate 95% confidence interval. A: rarefaction curves for the 6 census localities with > 300 specimens using all morphotypes. These curves show the overbank flora had greater rarefied richness than the pond flora. B: rarefaction curves for the 6 census localities using only dicot angiosperm leaves. These curves indicate that dicot angiosperms made up a greater proportion of species in overbank localities compared to pond localities

Figure 4 – A: Detrended correspondence analysis (DCA) scatter plot of all San Juan Basin census localities and morphotypes. Localities clustered by their floral facies with the pond floras located on the left side of the plot and the overbank facies in the upper right. There was a closer relationship between morphotypes found in individual overbank facies localities compared to pond facies localities. B: Dendrogram of six San Juan Basin census localities showing two major clusters of localities. Dendrogram generated using the Raup-Crick index (Raup and Crick, 1979). Localities clustered together based on their depositional facies. Percentages at each branching point indicate percentage of 10,000 iterations that branching point appeared. In 100% of runs, the two overbank and four pond localities formed separate clusters.

Figure 5 – Comparison of SJB rarefaction to other basins (Grey – SJB, Red – Denver basin, yellow – Williston basin (Wilf and Johnson 2004), blue – Williston basin (Peppe 2010); A – all groups by site, B – only dicots by site, C – all groups basin wide, D – only dicots basin wide; for A and B only the most and least diverse sites from DB and WB are shown. When all plant groups are included, the SJB rarefied richness greater at both site (A) and basin (C) levels than previously locations. When only dicot angiosperm leaves are included, the SJB has higher rarefied richness at both the site (B) and basin (D) levels but the difference is smaller than when all groups are included indicating a larger proportion of the SJB flora are non-dicot angiosperms compared to other basins.

Figure 6 – Modern ecosystem plots with paleoclimate variables. The SJB flora corresponded with modern tropical seasonal forests using both DiLP and LMA + LAA. Both the DB and WB

951 corresponded with warm and cool temperate forests respectively indicating the SJB represents a
952 different biome than previously studied localities. 95% confidence intervals for all paleoclimate
953 estimates shown by grey bars.

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955 Figure 1—

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960 Figure 3 —

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962 Figure 4 —

Figure 5 —

967 Figure 6 —

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Appendix 1 – Ojo Alamo Sandstone Morphotype Catalog

Morphological descriptions, botanical affinities, photographs, and line drawings of all identified Ojo Alamo Sandstone megafloral morphotypes. All dicotyledonous angiosperm leaf morphotypes were described using the *Manual of Leaf Architecture* (Ellis et al. 2009). Each dicotyledonous angiosperm leaf morphotype description contains leaf architecture description, margin classification, and Raunkiaer-Webb (Webb 1959) size classification. All other groups (i.e. dicotyledonous angiosperm reproductive structures, pteridophytes, monocotyledonous angiosperms, and conifers) were described based on their gross morphology. Botanical affinities of morphotypes were determined after comparison with previously published taxonomy. Each morphotype also has a specimen number which corresponds with the morphotype exemplar. See Supplementary Table 1 for detailed systematic morphotype list and Supplementary Table 2 for morphotype abundance by fossil locality.

Morphotype SJ-13	Major Plant Group Dicot	Organ Leaf
Family Cercidiphyllaceae	Genus and Species <i>"Populus" nebrascensis</i>	Exemplar Spec. # AF1407-077

Notes

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1° Primary vein framework	basal actinodromous
Leaf arrangement		naked basal veins	Absent
Leaf organization	simple	number of basal veins	5 to 7
Leaflet organization		agrophic veins	Simple
Leaflet attachment		2° Major 2° vein framework	Craspedodromous
Petiole features		Interior secondaries	Absent
Features of the blade:		minor secondary course	Craspedodromous
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	noto-mesophyll	major secondary spacing	abruptly increasing proximally
Laminar L:W ratio	~1.75:1 to ~2:1	Variation of secondary angle	Inconsistent
Laminar shape	ovate to elliptic	Major secondary attachment	Excurent
Medial symmetry	symmetrical	intersecondary proximal course	
Base symmetry	symmetrical	intersecondary length	
Lobation	unlobed	intersecondary distal course	
Margin type	serrate	intersecondary vein frequency	
Special margin features		3° Intercostal tertiary vein fabric	convex opposite percurrent
Apex angle	acute	Angle of percurrent tertiaries	obtuse exterior/acute interior
Apex shape	not visible	vein angle variability	increasing exmedially
Base angle	obtuse	Epimedial tertiaries	opposite percurrent
Base shape	rounded	proximal course	acute to midvein
Terminal apex features		distal course	Basiflexed
Surface texture		Exterior tertiary course	terminating at the margin
Surficial glands		4° Quaternary vein fabric	alternate percurrent
Sect. III - Teeth		5° Quintenary vein fabric	
Tooth spacing	regular	Areolation	
Number of orders of teeth	1	FEV branching	
Teeth / cm	2 to 3	FEV termination	
Sinus shape	rounded	Marginal Ultimate venation	
Tooth shapes	RT/CV		
Principal vein	present		
Principal vein termination	at apex of tooth		
Course of accessory vein			
Features of the tooth apex

Morphotype SJ-14	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # DP1301B-094

Notes

Arrow on photo B indicates morphotype SJ-14

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment		1° Primary vein framework	pinnate
Leaf arrangement		naked basal veins	absent
Leaf organization	simple	number of basal veins	1
Leaflet organization		agrophic veins	absent
Leaflet attachment		2° Major 2° vein framework	craspedodromous
Petiole features		Interior secondaries	absent
Features of the blade:		minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	notophyll	major secondary spacing	inconsistent
Laminar L:W ratio	~1.2:1	Variation of secondary angle	inconsistent
Laminar shape	elliptic	Major secondary attachment	excurrent
Medial symmetry	symmetrical	intersecondary proximal course	perpendicular to midvein
Base symmetry	symmetrical	intersecondary length	>50% of subjacent secondary
Lobation	unlobed	intersecondary distal course	para to sub major 2° to basiflex
Margin type	entire	intersecondary vein frequency	~ 1 per intercostal area
Special margin features		3° Intercostal tertiary vein fabric	irregular reticulate
Apex angle		Angle of percurrent tertiaries	
Apex shape		vein angle variability	
Base angle	acute	Epimedial tertiaries	reticulate
Base shape	straight	proximal course	
Terminal apex features		distal course	
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	irregular reticulate
Sect. III - Teeth		5° Quintenary vein fabric	
Tooth spacing		Areolation	moderate development
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype SJ-25	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1407B-C-009

Notes

One partial leaf fragment in Ojo Alamo Sandstone. Complete specimen of morphotype present in Nacimiento formation.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment		1° Primary vein framework	pinnate
Leaf arrangement		naked basal veins	absent
Leaf organization	simple	number of basal veins	1
Leaflet organization		agrophic veins	present
Leaflet attachment		2° Major 2° vein framework	eucamptodromous
Petiole features		Interior secondaries	absent
Features of the blade:		minor secondary course	simple brochidodromous
Position of lamina attachment		Perimarginal veins	
Laminar size	microphyll	major secondary spacing	irregular
Laminar L:W ratio		Variation of secondary angle	inconsistent
Laminar shape	elliptic	Major secondary attachment	excurrent
Medial symmetry	symmetrical	intersecondary proximal course	
Base symmetry		intersecondary length	
Lobation	unlobed	intersecondary distal course	
Margin type	entire	intersecondary vein frequency	
Special margin features		3° Intercostal tertiary vein fabric	straight opposite percurrent
Apex angle	obtuse	Angle of percurrent tertiaries	obtuse/perpendicular
Apex shape	convex	vein angle variability	inconsistent
Base angle		Epimedial tertiaries	mixed percurrent
Base shape		proximal course	acute/perpendicular to midvein
Terminal apex features		distal course	basiflexed
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	mixed percurrent
Sect. III - Teeth		5° Quintenary vein fabric	irregular reticulate
Tooth spacing		Areolation	good development
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype SJ-28	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1407B-C-008

Notes

One partial leaf fragment in Ojo Alamo Sandstone. Complete specimen of morphotype present in Nacimiento formation

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment		1° Primary vein framework	pinnate
Leaf arrangement		naked basal veins	absent
Leaf organization	simple	number of basal veins	1
Leaflet organization		agrophic veins	
Leaflet attachment		2° Major 2° vein framework	simple brochidodromous
Petiole features		Interior secondaries	absent
Features of the blade:		minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	mesophyll	major secondary spacing	irregular
Laminar L:W ratio	2.1:1	Variation of secondary angle	smoothly increasing proximally
Laminar shape	elliptic	Major secondary attachment	excurent
Medial symmetry	symmetrical	intersecondary proximal course	parallel to major secondaries
Base symmetry	symmetrical	intersecondary length	<50% of subjacent secondary
Lobation	unlobed	intersecondary distal course	perpendicular to secondary
Margin type	entire	intersecondary vein frequency	< 1 per intercostal area
Special margin features		3° Intercostal tertiary vein fabric	mixed percurrent
Apex angle	obtuse	Angle of percurrent tertiaries	obtuse
Apex shape	rounded	vein angle variability	decreasing exmedially
Base angle	obtuse	Epimedial tertiaries	opposite percurrent
Base shape	rounded	proximal course	perpendicular/obtuse to midvein
Terminal apex features		distal course	basiflexed & parallel to tertiary
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	mixed percurrent
Sect. III - Teeth		5° Quintenary vein fabric	freely ramifying
Tooth spacing		Areolation	moderate development
Number of orders of teeth		FEV branching	2+ with dendritic branching
Teeth / cm		FEV termination	simple
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

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Site: AF
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Specimen

Morphotype SJ-36	Major Plant Group Dicot	Organ Leaf
Family Platanaceae	Genus and Species <i>Platanites raynoldsii</i>	Exemplar Spec. # AF1409D-035A

Notes

Photo A shows lobed terminal leaflet. Photo B shows attached lateral leaflet.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1° Primary vein framework	basal actinodromous
Leaf arrangement		naked basal veins	absent
Leaf organization	compound	number of basal veins	3
Leaflet organization	unknown	agrophic veins	simple
Leaflet attachment	petiolulate	2° Major 2° vein framework	craspedodromous
Petiole features		Interior secondaries	absent
Features of the blade:		minor secondary course	craspedodromous
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	noto-macrophyll	major secondary spacing	decreasing proximally
Laminar L:W ratio	1.5:1	Variation of secondary angle	uniform
Laminar shape	ovate	Major secondary attachment	excurent
Medial symmetry	symmetrical	intersecondary proximal course	
Base symmetry	symmetrical	intersecondary length	
Lobation	unlobed and palmately lobed	intersecondary distal course	
Margin type	serrate	intersecondary vein frequency	
Special margin features		3° Intercostal tertiary vein fabric	mixed percurrent
Apex angle	acute	Angle of percurrent tertiaries	obtuse/perpendicular
Apex shape	straight	vein angle variability	increasing proximally
Base angle	obtuse	Epimedial tertiaries	opposite percurrent
Base shape	concave	proximal course	perpendicular/acute to midvein
Terminal apex features		distal course	basiflexed & parallel to tertiary
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	mixed percurrent
Sect. III - Teeth		5° Quintenary vein fabric	regular reticulate
Tooth spacing	irregular	Areolation	good development
Number of orders of teeth	two	FEV branching	mostly one branched
Teeth / cm	2 to 3	FEV termination	simple
Sinus shape	angular and rounded	Marginal Ultimate venation	looped
Tooth shapes	CC/ST, ST/CC, CV/CV		
Principal vein	present		
Principal vein termination	at apex of tooth		
Course of accessory vein	looped		
Features of the tooth apex			

A

B

Morphotype SJ-46	Major Plant Group Dicot	Organ Leaf
Family Oxidalaceae	Genus and Species <i>Averrhoites affinis</i>	Exemplar Spec. # AF1404-C2-036A

Notes

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1 ^o Primary vein framework	pinnate
Leaf arrangement		naked basal veins	absent
Leaf organization	compound	number of basal veins	1
Leaflet organization	unknown	agrophic veins	
Leaflet attachment	petiolulate	2 ^o Major 2° vein framework	simple brochidodromous
Petiole features		Interior secondaries	absent
Features of the blade:		minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	not applicable
Laminar size	micro-mesophyll	major secondary spacing	irregular
Laminar L:W ratio	3:1	Variation of secondary angle	inconsistent
Laminar shape	elliptic	Major secondary attachment	decurent & excurrent
Medial symmetry	asymmetrical	intersecondary proximal course	parallel to major secondaries
Base symmetry	basal width asymmetrical	intersecondary length	<50% of subjacent secondary
Lobation	unlobed	intersecondary distal course	ramifying
Margin type	entire	intersecondary vein frequency	< 1 per intercostal area
Special margin features		3 ^o Intercostal tertiary vein fabric	sinuous percurrent & reticulate
Apex angle	acute	Angle of percurrent tertiaries	obtuse
Apex shape	convex	vein angle variability	decreasing exmedially
Base angle	acute	Epimedial tertiaries	opposite percurrent
Base shape	convex, straight	proximal course	acute to midvein/ parallel to 2°
Terminal apex features		distal course	basiflexed
Surface texture		Exterior tertiary course	looped
Surficial glands		4 ^o Quaternary vein fabric	mixed percurrent
Sect. III - Teeth		5 ^o Quintenary vein fabric	irregular reticulate/ramifying
Tooth spacing		Areolation	poor development
Number of orders of teeth		FEV branching	2+ with dendritic branching
Teeth / cm		FEV termination	simple/tracheoid idioblasts
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex			

A

B

Morphotype	Major Plant Group	Organ
SJ-48	Dicot	Leaf
Family	Genus and Species	Exemplar Spec. #
	<i>incertae sedis</i>	DP1301B-086

Notes

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment		1 ^o Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization		Number of basal veins	1
Leaflet organization		Agrophic veins	
Leaflet attachment		2 ^o Major 2 ^o vein framework	simple brochidodromous
Petiole features		Interior secondaries	absent
Features of the blade:		Minor secondary course	
Position of lamina attachment		Perimarginal veins	
Laminar size	mesophyll	Major secondary spacing	irregular
Laminar L:W ratio		Variation of secondary angle	uniform
Laminar shape	elliptic/obovate	Major secondary attachment	excurrent
Medial symmetry	symmetrical	Intersecondary proximal course	
Base symmetry		Intersecondary length	
Lobation	unlobed	Intersecondary distal course	
Margin type	entire	Intersecondary vein frequency	
Special margin features		3 ^o Intercostal tertiary vein fabric	straight opposite percurrent
Apex angle		Angle of percurrent tertiaries	obtuse
Apex shape		Vein angle variability	decreasing exmedially
Base angle		Epimedial tertiaries	opposite percurrent
Base shape		Proximal course	perpendicular to midvein
Terminal apex features		Distal course	parallel to intercostal tertiary
Surface texture		Exterior tertiary course	looped
Surficial glands		4 ^o Quaternary vein fabric	mixed percurrent
Sect. III - Teeth		5 ^o Quintenary vein fabric	irregular reticulate/ramifying
Tooth spacing		Areolation	moderate development
Number of orders of teeth		FEV branching	mostly unbranched
Teeth / cm		FEV termination	simple
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype SJ-50	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # DP1301B-084

Notes

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment		1° Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization		Number of basal veins	1
Leaflet organization		Agrophic veins	
Leaflet attachment		2° Major 2° vein framework	eucamptodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	microphyll	Major secondary spacing	irregular
Laminar L:W ratio		Variation of secondary angle	smoothly increasing proximally
Laminar shape	elliptic/ovate	Major secondary attachment	basally decurrent
Medial symmetry	symmetrical	Intersecondary proximal course	parallel to major secondaries
Base symmetry		Intersecondary length	<50% of subjacent secondary
Lobation	unlobed	Intersecondary distal course	reticulate & perpindicular to 2°
Margin type	entire	Intersecondary vein frequency	< 1 per intercostal area
Special margin features		3° Intercostal tertiary vein fabric	irregular reticulate
Apex angle		Angle of percurrent tertiaries	
Apex shape		Vein angle variability	
Base angle		Epimedial tertiaries	reticulate
Base shape		Proximal course	
Terminal apex features		Distal course	
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	freely ramifying
Sect. III - Teeth		5° Quintenary vein fabric	
Tooth spacing		Areolation	poor development
Number of orders of teeth		FEV branching	mostly unbranched
Teeth / cm		FEV termination	simple
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype SJ-51	Major Plant Group Dicot	Organ Leaf
Family Nymphaeaceae	Genus and Species <i>Paranymphea crassifolia</i>	Exemplar Spec. # DP1301B-105

Notes

Sect. I - Leaf Characters			Sect. II - Venation		
Leaf attachment	petiolate	1 ^o	Primary vein framework	basal actinodromous	
Leaf arrangement			Naked basal veins		
Leaf organization	simple		Number of basal veins	5 to 7	
Leaflet organization			Agrophic veins		
Leaflet attachment		2 ^o	Major 2 ^o vein framework	simple brochidodromous	
Petiole features			Interior secondaries		
Features of the blade:			Minor secondary course		
			Perimarginal veins		
Position of lamina attachment	marginal/peltate		Major secondary spacing	decreasing proximally	
Laminar size	mesophyll		Variation of secondary angle	inconsistent	
Laminar L:W ratio	1.2:1		Major secondary attachment	deflected	
Laminar shape	ovate		Intersecondary proximal course	parallel to major secondaries	
Medial symmetry	symmetrical		Intersecondary length	<50% of subjacent secondary	
Base symmetry	symmetrical		Intersecondary distal course	reticulating	
Lobation	unlobed		Intersecondary vein frequency	< 1 per intercostal area	
Margin type	entire	3 ^o	Intercostal tertiary vein fabric	irregular reticulate	
Special margin features			Angle of percurrent tertiaries		
Apex angle	acute		Vein angle variability		
Apex shape	straight/convex		Epimedial tertiaries	reticulate	
Base angle	obtuse		Proximal course		
Base shape	cordate/rounded		Distal course		
Terminal apex features		4 ^o	Exterior tertiary course	looped	
Surface texture			Quaternary vein fabric	regular reticulate	
Surficial glands			Quintenary vein fabric	irregular reticulate	
Sect. III - Teeth			Areolation	good development	
		FEV branching	unbranched or 1 branched		
Tooth spacing		FEV termination	simple		
Number of orders of teeth			Marginal Ultimate venation	looped	
Teeth / cm					
Sinus shape					
Tooth shapes					
Principal vein					
Principal vein termination					
Course of accessory vein					
Features of the tooth apex

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Morphotype SJ-53	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1407-C-006

Notes

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment		1° Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization	simple	Number of basal veins	1
Leaflet organization		Agrophic veins	
Leaflet attachment		2° Major 2° vein framework	reticulodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	microphyll	Major secondary spacing	irregular
Laminar L:W ratio	1.75:1	Variation of secondary angle	inconsistent
Laminar shape	elliptic	Major secondary attachment	decurrent
Medial symmetry	asymmetrical	Intersecondary proximal course	perpendicular to midvein
Base symmetry	basal insertion asymmetrical	Intersecondary length	<50% of subjacent secondary
Lobation	unlobed	Intersecondary distal course	reticulating
Margin type	entire	Intersecondary vein frequency	< 1 per intercostal area
Special margin features		3° Intercostal tertiary vein fabric	irregular reticulate
Apex angle	reflex	Angle of percurrent tertiaries	
Apex shape	retuse	Vein angle variability	
Base angle	acut	Epimedial tertiaries	reticulate
Base shape	convex, concave	Proximal course	
Terminal apex features		Distal course	
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	irregular reticulate
Sect. III - Teeth		5° Quintenary vein fabric	freely ramifying
Tooth spacing		Areolation	moderate development
Number of orders of teeth		FEV branching	mostly unbranched
Teeth / cm		FEV termination	simple
Sinus shape		Marginal Ultimate venation	incomplete loops
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype	Major Plant Group	Organ
SJ-54	Dicot	Seed
Family	Genus and Species	Exemplar Spec. #
	<i>incertae sedis</i>	AF1407-C-013

Notes

Small, oblong seed with pointed apex and flat base. Seed is approximately 0.5 cm long and 0.2 cm wide. Seed has relatively smooth exterior.

Morphotype SJ-55	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1402-012

Notes

Multistranded midvein. Major secondary bifurcation

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment		1° Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization	simple	Number of basal veins	1
Leaflet organization		Agrophic veins	
Leaflet attachment		2° Major 2° vein framework	eucamptodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	microphyll	Major secondary spacing	irregular
Laminar L:W ratio	~1.75:1	Variation of secondary angle	inconsistent
Laminar shape	obovate	Major secondary attachment	decurent
Medial symmetry		Intersecondary proximal course	parallel to major secondaries
Base symmetry		Intersecondary length	>50% of subjacent secondary
Lobation	unlobed	Intersecondary distal course	para to subjacent major 2o
Margin type	entire	Intersecondary vein frequency	< 1 per intercostal area
Special margin features		3° Intercostal tertiary vein fabric	irregular reticulate
Apex angle	obtuse	Angle of percurrent tertiaries	
Apex shape	rounded	Vein angle variability	
Base angle		Epimedial tertiaries	opposite percurrent
Base shape		Proximal course	parallel to secondary
Terminal apex features		Distal course	basiflexed
Surface texture		Exterior tertiary course	
Surficial glands		4° Quaternary vein fabric	irregular reticulate
Sect. III - Teeth		5° Quintenary vein fabric	freely ramifying
Tooth spacing		Areolation	poor development
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype	Major Plant Group	Organ
SJ-56	Fern	Leaf
Family	Genus and Species	Exemplar Spec. #
Onocleaceae	<i>Onoclea sensibilis</i>	AF1402-002

Notes

Fern frond. Bipinnate, Pinnatifid, tertiary veins dichotomous, fairly thick rachis, non-serrate margin, subtending leaf vein to major rachis

Morphotype	Major Plant Group	Organ
SJ-57	Fern	Leaf
Family	Genus and Species	Exemplar Spec. #
Anemiaceae	<i>"Anemia" sp.</i>	AF1402-016

Notes

Fern frond. Pinnatifid pinus, serrate margin, becomes more dissected towards base, secondary and tertiary veins more dichotomous towards apex, frond ~6-10 cm long, pinus nearly vertical.

Morphotype SJ-58	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1407-C-008

Notes

Multistranded midvein, sinuous margin, pore ("pock marks") on or near mid vein which are less than 10 mm across. A is photo of morphotype exemplar, B is line drawing of primary, secondary, and tertiary venation.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment		1° Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization		Number of basal veins	1
Leaflet organization		Agrophic veins	
Leaflet attachment		2° Major 2° vein framework	euamptodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	notophyll	Major secondary spacing	abruptly increasing proximally
Laminar L:W ratio	~2:1	Variation of secondary angle	
Laminar shape	obovate	Major secondary attachment	decurrent
Medial symmetry		Intersecondary proximal course	
Base symmetry		Intersecondary length	
Lobation	unlobed	Intersecondary distal course	
Margin type		Intersecondary vein frequency	
Special margin features	sinuous	3° Intercostal tertiary vein fabric	straight opposite percurrent
Apex angle	acute	Angle of percurrent tertiaries	obtuse
Apex shape		Vein angle variability	
Base angle		Epimedial tertiaries	opposite percurrent
Base shape		Proximal course	perpendicular to midvein
Terminal apex features		Distal course	parallel to intercostal tertiary
Surface texture		Exterior tertiary course	
Surficial glands		4° Quaternary vein fabric	
Sect. III - Teeth		5° Quintenary vein fabric	
Tooth spacing		Areolation	
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype	Major Plant Group	Organ
SJ-59	Lycophyte	Leaf
Family	Genus and Species	Exemplar Spec. #
Selaginellaceae	<i>Selaginella sp.</i>	AF1407-C-019

Notes

Small fronds (<1 cm), small scale-like leaves, leaflets alternate, bipinnate

Morphotype	Major Plant Group	Organ
SJ-60	Monocot	Leaf
Family	Genus and Species	Exemplar Spec. #
	<i>incertae sedis</i>	AF1407-C-020

Notes

Small, think monocot leaf (1.0-1.5 cm across). Pointed apex, wide base. Densely packed secondary veins

Morphotype	Major Plant Group	Organ
SJ-61	Fern	Leaf
Family	Genus and Species	Exemplar Spec. #
	<i>incertae sedis</i>	AF1402-011

Notes

Fern frond. Pinnatisect fern basally pinnatifid towards apex of pinnae. L:W ratio ~2:1. Pinnae are serrate. Veins dichotomize off primary vein into teeth and lobes.

Morphotype	Major Plant Group	Organ
SJ-62	Monocot	Leaf
Family	Genus and Species	Exemplar Spec. #
Araceae	<i>Limnobiophyllum scutatum</i>	AF1407-C-003

Notes

Small, round aquatic leaf (~1-1.5 cm across). Relatively thin, root strands at base, usually found in pairs.

Morphotype	Major Plant Group	Organ
SJ-63	Dicot	Leaf
Family	Genus and Species	Exemplar Spec. #
	<i>incertae sedis</i>	AF1407-C-002

Notes

Thick, multistranded midvein

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment		1 ^o Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization	simple	Number of basal veins	1
Leaflet organization		Agrophic veins	
Leaflet attachment		2 ^o Major 2 ^o vein framework	reticulodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	notophyll	Major secondary spacing	irregular
Laminar L:W ratio	~2:1	Variation of secondary angle	inconsistent
Laminar shape	obovate	Major secondary attachment	basally decurrent
Medial symmetry	asymmetrical	Intersecondary proximal course	
Base symmetry		Intersecondary length	
Lobation	unlobed	Intersecondary distal course	
Margin type	entire	Intersecondary vein frequency	
Special margin features		3 ^o Intercostal tertiary vein fabric	exmedially ramified
Apex angle		Angle of percurrent tertiaries	
Apex shape		Vein angle variability	
Base angle		Epimedial tertiaries	
Base shape		Proximal course	
Terminal apex features		Distal course	
Surface texture		Exterior tertiary course	
Surficial glands		4 ^o Quaternary vein fabric	
Sect. III - Teeth		5 ^o Quintenary vein fabric	
Tooth spacing		Areolation	
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

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Morphotype	Major Plant Group	Organ
SJ-64	Horsetail	Leaf
Family	Genus and Species	Exemplar Spec. #
Equisetaceae	<i>Equisetum sp.</i>	AF1407B-C-007

Notes

Nodes approximately 1.5-2.0 cm, stem relatively narrow, two prominent rows of supporting tissue, small leaves present at nodes

Morphotype	Major Plant Group	Organ
SJ-65	Monocot	Leaf
Family	Genus and Species	Exemplar Spec. #
Zingiberaceae	<i>incertae sedis</i>	AF1407B-C-007

Notes

Bell shaped leaf, clamydromous venation, high density of primary veins, frequently found with prominent insect damage (see photo B).

Morphotype SJ-66	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1407-C-001

Notes

Each major secondary loop connects with an opening or pore in the margin. A is photo of morphotype exemplar, B is line drawing of major and minor secondary veins and margin pores.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment		1° Primary vein framework	
Leaf arrangement		Naked basal veins	
Leaf organization		Number of basal veins	
Leaflet organization		Agrophic veins	
Leaflet attachment		2° Major 2° vein framework	festooned brochidodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment		Perimarginal veins	
Laminar size		Major secondary spacing	
Laminar L:W ratio		Variation of secondary angle	
Laminar shape	circular	Major secondary attachment	
Medial symmetry		Intersecondary proximal course	
Base symmetry		Intersecondary length	
Lobation		Intersecondary distal course	
Margin type	entire	Intersecondary vein frequency	
Special margin features		3° Intercostal tertiary vein fabric	
Apex angle	obtuse	Angle of percurrent tertiaries	
Apex shape	rounded	Vein angle variability	
Base angle		Epimedial tertiaries	
Base shape		Proximal course	
Terminal apex features		Distal course	
Surface texture		Exterior tertiary course	
Surficial glands		4° Quaternary vein fabric	
Sect. III - Teeth		5° Quintenary vein fabric	
Tooth spacing		Areolation	
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype SJ-67	Major Plant Group Horsetail	Organ Reproductive structure
Family Equisetaceae	Genus and Species <i>Equisetum sp.</i>	Exemplar Spec. # AF1407B-C-016

Notes

Equisetum strobili which occur in pairs with hollow center and thickened outer rings. Reproductive structures are circular and approximately 0.5 cm in diameter

Morphotype	Major Plant Group	Organ
SJ-68	Conifer	Leaf
Family	Genus and Species	Exemplar Spec. #
Cupressaceae	<i>Cupressinocladus interruptis</i>	AF1407B-C-011

Notes

Small, scale-like leaves, cones when found are small (< 2 cm in length), leaves are alternate

Morphotype SJ-69	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1407B-C-013

Notes

Sect. I - Leaf Characters		Sect. II - Venation		
Leaf attachment	petiolate	1 ^o	Primary vein framework	pinnate
Leaf arrangement			Naked basal veins	
Leaf organization	simple		Number of basal veins	5 to 7
Leaflet organization			Agrophic veins	compound
Leaflet attachment		2 ^o	Major 2 ^o vein framework	simple brochidodromous
Petiole features			Interior secondaries	
Features of the blade:			Minor secondary course	simple brochidodromous
Position of lamina attachment	marginal		Perimarginal veins	
Laminar size	microphyll		Major secondary spacing	abruptly increasing proximally
Laminar L:W ratio			Variation of secondary angle	smoothly increasing proximally
Laminar shape			Major secondary attachment	excurrent
Medial symmetry			Intersecondary proximal course	
Base symmetry	symmetrical		Intersecondary length	
Lobation			Intersecondary distal course	
Margin type			Intersecondary vein frequency	
Special margin features		3 ^o	Intercostal tertiary vein fabric	mixed percurrent
Apex angle			Angle of percurrent tertiaries	obtuse
Apex shape			Vein angle variability	increasing exmedially
Base angle	reflex		Epimedial tertiaries	opposite percurrent
Base shape	complex, cordate		Proximal course	obtuse to midvein
Terminal apex features			Distal course	parallel to intercostal tertiary
Surface texture			Exterior tertiary course	looped
Surficial glands		4 ^o	Quaternary vein fabric	mixed percurrent
Sect. III - Teeth		5 ^o	Quintenary vein fabric	irregular reticulate
Tooth spacing			Areolation	good development
Number of orders of teeth			FEV branching	
Teeth / cm			FEV termination	
Sinus shape			Marginal Ultimate venation	looped
Tooth shapes				
Principal vein				
Principal vein termination				
Course of accessory vein				
Features of the tooth apex

Morphotype	Major Plant Group	Organ
SJ-70	Monocot	Seed
Family	Genus and Species	Exemplar Spec. #
Areaceae	<i>incertae sedis</i>	AF1407B-C-006

Notes

Round seed, approximately 0.7 cm in diameter, surface of seed has pebbled texture, expanding ring around midsection, proximal end of seed flattened

Morphotype SJ-71	Major Plant Group Dicot	Organ Leaf
Family Platanaceae	Genus and Species <i>Platanites marginata</i>	Exemplar Spec. # AF1409D-106

Notes

Compound leaf has 1 terminal leaflet and 2 lateral leaflets (Photo C). Terminal leaflet obovate and basal actinodromous with three basal veins (Photo A). Lateral leaflets usually pinnate, elliptic to obovate (Photo B).

Sect. I - Leaf Characters		Sect. II - Venation		
Leaf attachment	petiolate	1°	Primary vein framework	pinnate or basal actinodromous
Leaf arrangement			Naked basal veins	
Leaf organization	compound		Number of basal veins	1 to 3
Leaflet organization	unknown		Agrophic veins	compound
Leaflet attachment	petiolulate	2°	Major 2° vein framework	craspedodromous
Petiole features			Interior secondaries	
Features of the blade:			Minor secondary course	craspedodromous
Position of lamina attachment	marginal		Perimarginal veins	
Laminar size	noto- to mesophyll		Major secondary spacing	increasing proximally
Laminar L:W ratio	~1.5:1		Variation of secondary angle	uniform
Laminar shape	elliptic to obovate		Major secondary attachment	excurrent
Medial symmetry	symmetrical		Intersecondary proximal course	
Base symmetry	symmetrical		Intersecondary length	
Lobation	unlobed to palmately lobed		Intersecondary distal course	
Margin type	serrate		Intersecondary vein frequency	
Special margin features		3°	Intercostal tertiary vein fabric	convex opposite percurrent
Apex angle	acute and obtuse		Angle of percurrent tertiaries	obtuse
Apex shape	straight, rounded		Vein angle variability	decreasing exmedially
Base angle	acute and obtuse		Epimedial tertiaries	opposite percurrent
Base shape	straight, concave		Proximal course	acute to midvein
Terminal apex features			Distal course	parallel to intercostal tertiary
Surface texture			Exterior tertiary course	looped
Surficial glands		4°	Quaternary vein fabric	mixed percurrent
Sect. III - Teeth		5°	Quintenary vein fabric	irregular reticulate
Tooth spacing	irregular		Areolation	good development
Number of orders of teeth	two		FEV branching	
Teeth / cm	~2		FEV termination	
Sinus shape	rounded		Marginal Ultimate venation	
Tooth shapes	CC/ST, ST/ST, CC/CV			
Principal vein	present			
Principal vein termination	at apex of tooth			
Course of accessory vein				
Features of the tooth apex

Morphotype SJ-72	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1409D-103A/B

Notes

Secondary veins bifurcate towards margin. Photos A and B are part and counter part of exemplar.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment		1° Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization	palmately coupound	Number of basal veins	1
Leaflet organization		Agrophic veins	
Leaflet attachment		2° Major 2° vein framework	reticulo-/cladodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	nanophyll	Major secondary spacing	irregular
Laminar L:W ratio	~3:1	Variation of secondary angle	inconsistent
Laminar shape	elliptic/obovate	Major secondary attachment	decurent
Medial symmetry	asymmetrical	Intersecondary proximal course	
Base symmetry	basal width asymmetrical	Intersecondary length	
Lobation	unlobed	Intersecondary distal course	
Margin type	entire	Intersecondary vein frequency	
Special margin features		3° Intercostal tertiary vein fabric	exmedially ramified
Apex angle	obtuse	Angle of percurrent tertiaries	
Apex shape	rounded	Vein angle variability	
Base angle	acute	Epimedial tertiaries	ramified
Base shape	straight, concave	Proximal course	
Terminal apex features		Distal course	
Surface texture		Exterior tertiary course	terminating at the margin
Surficial glands		4° Quaternary vein fabric	
Sect. III - Teeth		5° Quintenary vein fabric	
Tooth spacing		Areolation	absent
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype SJ-73	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1409D-110A

Notes

Likely herbaceous. Leaf appears to be thin. Secondary veins both alternate and opposite.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1° Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization	simple	Number of basal veins	1
Leaflet organization		Agrophic veins	
Leaflet attachment		2° Major 2° vein framework	reticulodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	microphyll	Major secondary spacing	irregular
Laminar L:W ratio	5:1	Variation of secondary angle	inconsistent
Laminar shape	elliptic/obovate	Major secondary attachment	basally decurrent
Medial symmetry	asymmetrical	Intersecondary proximal course	parallel to major secondaries
Base symmetry	basal width asymmetrical	Intersecondary length	<50% of subjacent secondary
Lobation	unlobed	Intersecondary distal course	para to secondaries/reticulating
Margin type	entire	Intersecondary vein frequency	< 1 per intercostal area
Special margin features		3° Intercostal tertiary vein fabric	irregular reticulate
Apex angle		Angle of percurrent tertiaries	
Apex shape		Vein angle variability	
Base angle	acute	Epimedial tertiaries	reticulate
Base shape	straight	Proximal course	
Terminal apex features		Distal course	
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	irregular reticulate
Sect. III - Teeth		5° Quintenary vein fabric	freely ramifying
Tooth spacing		Areolation	poor development
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Mophotype:

Specimen #:

Morphotype SJ-76	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1409D-100

Notes

Thickened midvein. Likely herbaceous.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1° Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	not visible
Leaf organization	simple	Number of basal veins	1
Leaflet organization		Agrophic veins	absent
Leaflet attachment		2° Major 2° vein framework	semicraspedodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	notophyll	Major secondary spacing	decreasing proximally
Laminar L:W ratio	2:1	Variation of secondary angle	smoothly increasing proximally
Laminar shape	elliptic/obovate	Major secondary attachment	basally decurrent
Medial symmetry	symmetrical	Intersecondary proximal course	parallel to major secondaries
Base symmetry	symmetrical	Intersecondary length	<50% of subjacent secondary
Lobation	unlobed	Intersecondary distal course	reticulating
Margin type	serrate	Intersecondary vein frequency	< 1 per intercostal area
Special margin features		3° Intercostal tertiary vein fabric	irregular reticulate
Apex angle		Angle of percurrent tertiaries	
Apex shape		Vein angle variability	
Base angle	acute	Epimedial tertiaries	reticulate
Base shape	straight	Proximal course	
Terminal apex features		Distal course	
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	irregular reticulate
Sect. III - Teeth		5° Quintenary vein fabric	
Tooth spacing	irregular	Areolation	
Number of orders of teeth	two	FEV branching	
Teeth / cm	2 to 3	FEV termination	
Sinus shape	rounded	Marginal Ultimate venation	
Tooth shapes	RT/CV, CC/CV, ST/RT		
Principal vein	present		
Principal vein termination	at apex of tooth		
Course of accessory vein			
Features of the tooth apex

Morphotype SJ-77	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1409D-069

Notes

Secondary vein angle differs on each side of midvein. Apex of leaf frequently broken.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1° Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	not visible
Leaf organization	simple	Number of basal veins	1
Leaflet organization		Agrophic veins	simple
Leaflet attachment		2° Major 2° vein framework	craspedodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	craspedodromous
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	noto- to mesophyll	Major secondary spacing	decreasing proximally
Laminar L:W ratio	2.5:1	Variation of secondary angle	smoothly increasing proximally
Laminar shape	elliptic	Major secondary attachment	excurrent
Medial symmetry	asymmetrical	Intersecondary proximal course	
Base symmetry	basal width asymmetrical	Intersecondary length	
Lobation	unlobed	Intersecondary distal course	
Margin type	serrate	Intersecondary vein frequency	
Special margin features		3° Intercostal tertiary vein fabric	alternate percurrent
Apex angle	obtuse	Angle of percurrent tertiaries	obtuse
Apex shape	convex, rounded	Vein angle variability	decreasing exmedially
Base angle	obtuse	Epimedial tertiaries	alternate percurrent
Base shape	concavo-convex	Proximal course	perpendicular to midvein
Terminal apex features		Distal course	parallel to intercostal tertiary
Surface texture		Exterior tertiary course	variable
Surficial glands		4° Quaternary vein fabric	alternate percurrent
Sect. III - Teeth		5° Quintenary vein fabric	regular reticulate
Tooth spacing	irregular	Areolation	good development
Number of orders of teeth	two	FEV branching	mostly one branched
Teeth / cm	2 to 3	FEV termination	simple
Sinus shape	rounded	Marginal Ultimate venation	looped
Tooth shapes	RT/ST, ST/RT		
Principal vein	present		
Principal vein termination	at apex of tooth		
Course of accessory vein			
Features of the tooth apex

Morphotype SJ-78	Major Plant Group Dicot	Organ Leaf
Family Nyssaceae	Genus and Species <i>Browneia serrata</i>	Exemplar Spec. # AF1409D-030

Notes

Major secondary veins subopposite. Secondary vein angle high. Variable leaf shape with more obovate leaves in overbank facies (Photo A) and more elliptic leaves in ponded facies (Photo B). Morphotypes SJ-52 and SJ-75 sunk into this morphotype.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1 ^o Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	not visible
Leaf organization	simple	Number of basal veins	1
Leaflet organization		Agrophic veins	simple
Leaflet attachment		2 ^o Major 2 ^o vein framework	semicraspedodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	noto- to mesophyll	Major secondary spacing	irregular
Laminar L:W ratio	3.5:1	Variation of secondary angle	uniform
Laminar shape	elliptic/obovate	Major secondary attachment	excurrent
Medial symmetry	symmetrical	Intersecondary proximal course	
Base symmetry	symmetrical	Intersecondary length	
Lobation	unlobed	Intersecondary distal course	
Margin type	serrate	Intersecondary vein frequency	
Special margin features		3 ^o Intercostal tertiary vein fabric	mixed percurrent
Apex angle	acute to obtuse	Angle of percurrent tertiaries	obtuse
Apex shape	straight	Vein angle variability	decreasing exmedially
Base angle	obtuse	Epimedial tertiaries	opposite percurrent
Base shape	rounded to concavo-convex	Proximal course	acute/perpendicular to midvein
Terminal apex features		Distal course	parallel to intercostal tertiary
Surface texture		Exterior tertiary course	looped
Surficial glands		4 ^o Quaternary vein fabric	irregular reticulate
Sect. III - Teeth		5 ^o Quintenary vein fabric	irregular reticulate
Tooth spacing	regular	Areolation	good development
Number of orders of teeth	one	FEV branching	mostly one branched
Teeth / cm	3 to 4	FEV termination	simple
Sinus shape	angular	Marginal Ultimate venation	looped
Tooth shapes	ST/FL, ST/CC		
Principal vein	present		
Principal vein termination	at apex of tooth		
Course of accessory vein			
Features of the tooth apex

Morphotype	Major Plant Group	Organ
SJ-79	Monocot	Leaf
Family	Genus and Species	Exemplar Spec. #
	<i>incertae sedis</i>	AF1409D-104A

Notes

Large monocot leaf approximately 2.5 cm wide. Major secondary vein density increases towards margin. Approximately 10 secondary veins on each side of midvein.

Morphotype SJ-80	Major Plant Group Dicot	Organ Leaf
Family Rhamnaceae	Genus and Species <i>"Rhamnus" goldiana</i>	Exemplar Spec. # AF1409D-027

Notes

Dense well impressed tertiary veins. Secondary veins occasionally bifurcate.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1° Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization	simple	Number of basal veins	1
Leaflet organization		Agrophic veins	simple
Leaflet attachment		2° Major 2° vein framework	simple brochidodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	simple brochidodromous
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	notophyll	Major secondary spacing	decreasing proximally
Laminar L:W ratio	1.7:1	Variation of secondary angle	smoothly increasing proximally
Laminar shape	ovate	Major secondary attachment	excurent
Medial symmetry	symmetrical	Intersecondary proximal course	
Base symmetry	symmetrical	Intersecondary length	
Lobation	unlobed	Intersecondary distal course	
Margin type	entire	Intersecondary vein frequency	
Special margin features		3° Intercostal tertiary vein fabric	straight opposite percurrent
Apex angle	acute and obtuse	Angle of percurrent tertiaries	obtuse
Apex shape	straight, rounded	Vein angle variability	increasing proximally
Base angle	obtuse	Epimedial tertiaries	opposite percurrent
Base shape	convex	Proximal course	obtuse/perpendicular to midvein
Terminal apex features		Distal course	parallel to intercostal tertiary
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	opposite percurrent
Sect. III - Teeth		5° Quintenary vein fabric	regular reticulate
Tooth spacing		Areolation	good
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype SJ-81	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1409D-056A

Notes

Large gap between basal primary veins and first secondary vein. Tertiary veins dense and well impressed.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1° Primary vein framework	basal actinodromous
Leaf arrangement		Naked basal veins	
Leaf organization	simple	Number of basal veins	3
Leaflet organization		Agrophic veins	simple
Leaflet attachment		2° Major 2° vein framework	simple brochidodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	simple brochidodromous
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	mesophyll	Major secondary spacing	uniform
Laminar L:W ratio	1.2:1	Variation of secondary angle	abruptly increasing proximally
Laminar shape	ovate	Major secondary attachment	excurrent
Medial symmetry	symmetrical	Intersecondary proximal course	
Base symmetry	symmetrical	Intersecondary length	
Lobation	unlobed	Intersecondary distal course	
Margin type	entire	Intersecondary vein frequency	
Special margin features		3° Intercostal tertiary vein fabric	straight opposite percurrent
Apex angle		Angle of percurrent tertiaries	obtuse
Apex shape		Vein angle variability	increasing exmedially/proximally
Base angle	obtuse	Epimedial tertiaries	opposite percurrent
Base shape	rounded	Proximal course	perpendicular to midvein
Terminal apex features		Distal course	parallel to intercostal tertiary
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	mixed percurrent
Sect. III - Teeth		5° Quintenary vein fabric	regular reticulate
Tooth spacing		Areolation	good
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Site: AF1409D

Mophotype: SJ-81

Specimen #: AF1409D-056
0004

Morphotype SJ-82	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1409D-006

Notes

Fleshy, thick petiole. High density of major secondary veins. Large variation in leaf size.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1° Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization	simple	Number of basal veins	1
Leaflet organization		Agrophic veins	not visible
Leaflet attachment		2° Major 2° vein framework	festooned brochidodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	noto- to mesophyll	Major secondary spacing	irregular
Laminar L:W ratio	6:1	Variation of secondary angle	smoothly increasing proximally
Laminar shape	obovate to linear	Major secondary attachment	basally decurrent
Medial symmetry	symmetrical	Intersecondary proximal course	parallel to major secondaries
Base symmetry	symmetrical	Intersecondary length	<50% of subjacent secondary
Lobation	unlobed	Intersecondary distal course	reticulating
Margin type	entire	Intersecondary vein frequency	~ 1 per intercostal area
Special margin features		3° Intercostal tertiary vein fabric	irregular reticulate
Apex angle	ontuse	Angle of percurrent tertiaries	
Apex shape	rounded	Vein angle variability	
Base angle	acute	Epimedial tertiaries	reticulate
Base shape	straight	Proximal course	
Terminal apex features		Distal course	
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	irregular reticulate
Sect. III - Teeth		5° Quintenary vein fabric	freely ramifying
Tooth spacing		Areolation	poor development
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype SJ-83	Major Plant Group Dicot	Organ Leaf
Family <i>Dicotylophyllum</i>	Genus and Species <i>horsecreekium</i>	Exemplar Spec. # AF1409D-086

Notes

Sect. I - Leaf Characters		Sect. II - Venation		
Leaf attachment	petiolate	1 ^o	Primary vein framework	basal actinodromous
Leaf arrangement			Naked basal veins	
Leaf organization	simple		Number of basal veins	5 to 7
Leaflet organization			Agrophic veins	simple
Leaflet attachment		2 ^o	Major 2 ^o vein framework	simple brochidodromous
Petiole features			Interior secondaries	
Features of the blade:			Minor secondary course	simple brochidodromous
Position of lamina attachment	marginal		Perimarginal veins	
Laminar size	notophyll		Major secondary spacing	decreasing proximally
Laminar L:W ratio	1.5:1		Variation of secondary angle	abruptly increasing proximally
Laminar shape	ovate		Major secondary attachment	excurrent
Medial symmetry	symmetrical		Intersecondary proximal course	
Base symmetry	symmetrical		Intersecondary length	
Lobation	unlobed		Intersecondary distal course	
Margin type	entire		Intersecondary vein frequency	
Special margin features		3 ^o	Intercostal tertiary vein fabric	straight opposite percurrent
Apex angle			Angle of percurrent tertiaries	obtuse/perpendicular
Apex shape			Vein angle variability	increasing proximally
Base angle	reflex		Epimedial tertiaries	opposite percurrent
Base shape	cordate		Proximal course	perpendicular to midvein
Terminal apex features			Distal course	parallel to intercostal tertiary
Surface texture			Exterior tertiary course	looped
Surficial glands		4 ^o	Quaternary vein fabric	mixed percurrent
Sect. III - Teeth		5 ^o	Quintenary vein fabric	regular reticulate
Tooth spacing			Areolation	good
Number of orders of teeth			FEV branching	
Teeth / cm			FEV termination	
Sinus shape			Marginal Ultimate venation	looped
Tooth shapes				
Principal vein				
Principal vein termination				
Course of accessory vein				
Features of the tooth apex

Morphotype	Major Plant Group	Organ
SJ-86	Monocot	Leaf
Family	Genus and Species	Exemplar Spec. #
	<i>incertae sedis</i>	AF1409D-071

Notes

Thin monocot approximately 0.75 to 1.0 cm wide. Vein density increases towards midvein, decreases towards margin. Approximately 8 veins between midvein and margin.

Morphotype SJ-88	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1409C-025

Notes

Setaceous teeth with some hairs present. Major secondary semicraspedodromous loops angular/polygonal.

Sect. I - Leaf Characters		Sect. II - Venation		
Leaf attachment		1°	Primary vein framework	basal actinodromous
Leaf arrangement			Naked basal veins	
Leaf organization	simple		Number of basal veins	3
Leaflet organization			Agrophic veins	simple
Leaflet attachment		2°	Major 2° vein framework	semicraspedodromous
Petiole features			Interior secondaries	
Features of the blade:			Minor secondary course	semicraspedodromous
Position of lamina attachment			Perimarginal veins	
Laminar size	mesophyll		Major secondary spacing	irregular
Laminar L:W ratio	1.5:1		Variation of secondary angle	smoothly decreasing proximally
Laminar shape	ovate to elliptic		Major secondary attachment	excurrent
Medial symmetry	symmetrical		Intersecondary proximal course	perpendicular to midvein
Base symmetry	symmetrical		Intersecondary length	<50% of subjacent secondary
Lobation	unlobed		Intersecondary distal course	perpendicular to secondary
Margin type	serrate		Intersecondary vein frequency	< 1 per intercostal area
Special margin features		3°	Intercostal tertiary vein fabric	straight opposite percurrent
Apex angle	obtuse		Angle of percurrent tertiaries	obtuse
Apex shape	straight		Vein angle variability	decreasing exmedially
Base angle			Epimedial tertiaries	opposite percurrent
Base shape			Proximal course	perpendicular to midvein
Terminal apex features			Distal course	parallel to intercostal tertiary
Surface texture			Exterior tertiary course	looped
Surficial glands		4°	Quaternary vein fabric	
Sect. III - Teeth		5°	Quintenary vein fabric	
Tooth spacing	regular		Areolation	
Number of orders of teeth	2		FEV branching	
Teeth / cm	1		FEV termination	
Sinus shape	rounded and angular		Marginal Ultimate venation	
Tooth shapes	RT/CV, ST/CV			
Principal vein	present			
Principal vein termination	at apex of tooth			
Course of accessory vein				
Features of the tooth apex	setaceous

Site: AF1409C-

Mophotype: SJ-88 (

Specimen #: AF1409

Morphotype SJ-89	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1409D-076

Notes

Primary vein thick. Secondary veins nearly perpendicular to midvein.

Sect. I - Leaf Characters		Sect. II - Venation		
Leaf attachment		1°	Primary vein framework	pinnate
Leaf arrangement			Naked basal veins	
Leaf organization			Number of basal veins	1
Leaflet organization			Agrophic veins	
Leaflet attachment		2°	Major 2° vein framework	
Petiole features			Interior secondaries	
Features of the blade:			Minor secondary course	
Position of lamina attachment			Perimarginal veins	
Laminar size			Major secondary spacing	irregular
Laminar L:W ratio			Variation of secondary angle	increasing proximally
Laminar shape			Major secondary attachment	excurrent
Medial symmetry			Intersecondary proximal course	
Base symmetry			Intersecondary length	
Lobation			Intersecondary distal course	
Margin type			Intersecondary vein frequency	
Special margin features		3°	Intercostal tertiary vein fabric	sinuous opposite percurrent
Apex angle			Angle of percurrent tertiaries	obtuse
Apex shape			Vein angle variability	increasing proximally
Base angle			Epimedial tertiaries	opposite percurrent
Base shape			Proximal course	obtuse to midvein
Terminal apex features			Distal course	parallel to intercostal tertiary
Surface texture			Exterior tertiary course	
Surficial glands		4°	Quaternary vein fabric	mixed percurrent
Sect. III - Teeth		5°	Quintenary vein fabric	irregular reticulate
Tooth spacing			Areolation	moderately developed
Number of orders of teeth			FEV branching	
Teeth / cm			FEV termination	
Sinus shape			Marginal Ultimate venation	
Tooth shapes				
Principal vein				
Principal vein termination				
Course of accessory vein				
Features of the tooth apex

Morphotype SJ-90	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1409D-101

Notes

Possibly part of a winged seed or fruit.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1° Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization	simple	Number of basal veins	1
Leaflet organization		Agrophic veins	
Leaflet attachment		2° Major 2° vein framework	eucamptodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	notophyll	Major secondary spacing	irregular
Laminar L:W ratio	3:1	Variation of secondary angle	inconsistent
Laminar shape	elliptic	Major secondary attachment	excurrent
Medial symmetry	symmetrical	Intersecondary proximal course	
Base symmetry	symmetrical	Intersecondary length	
Lobation	unlobed	Intersecondary distal course	
Margin type	entire	Intersecondary vein frequency	
Special margin features		3° Intercostal tertiary vein fabric	
Apex angle	obtuse	Angle of percurrent tertiaries	
Apex shape	rounded	Vein angle variability	
Base angle	acute	Epimedial tertiaries	
Base shape	concave, straight	Proximal course	
Terminal apex features		Distal course	
Surface texture		Exterior tertiary course	
Surficial glands		4° Quaternary vein fabric	
Sect. III - Teeth		5° Quintenary vein fabric	
Tooth spacing		Areolation	
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype SJ-93	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1407-086A

Notes

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1 ^o Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization	simple	Number of basal veins	1
Leaflet organization		Agrophic veins	
Leaflet attachment		2 ^o Major 2 ^o vein framework	simple brochidodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	microphyll	Major secondary spacing	decreasing proximally
Laminar L:W ratio	3:1	Variation of secondary angle	abruptly increasing proximally
Laminar shape	elliptic	Major secondary attachment	excurrent
Medial symmetry	asymmetrical	Intersecondary proximal course	parallel to major secondaries
Base symmetry	basal width asymmetrical	Intersecondary length	<50% subadjacent secondary
Lobation	unlobed	Intersecondary distal course	reticulating
Margin type	entire	Intersecondary vein frequency	< 1 per intercostal area
Special margin features		3 ^o Intercostal tertiary vein fabric	irregular reticulate
Apex angle	acute	Angle of percurrent tertiaries	
Apex shape	convex	Vein angle variability	
Base angle	acute	Epimedial tertiaries	reticulate
Base shape	straight, convex	Proximal course	
Terminal apex features		Distal course	
Surface texture		Exterior tertiary course	looped
Surficial glands		4 ^o Quaternary vein fabric	freely ramifying
Sect. III - Teeth		5 ^o Quintenary vein fabric	freely ramifying
Tooth spacing		Areolation	poor development
Number of orders of teeth		FEV branching	mostly one branched
Teeth / cm		FEV termination	simple
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype	Major Plant Group	Organ
SJ-94	Dicot	Leaf
Family	Genus and Species	Exemplar Spec. #
	<i>incertae sedis</i>	AF1407-097

Notes

Sect. I - Leaf Characters		Sect. II - Venation		
Leaf attachment		1 ^o	Primary vein framework	pinnate
Leaf arrangement			Naked basal veins	
Leaf organization			Number of basal veins	1
Leaflet organization			Agrophic veins	
Leaflet attachment		2 ^o	Major 2° vein framework	simple brochidodromous
Petiole features			Interior secondaries	
Features of the blade:			Minor secondary course	
Position of lamina attachment	marginal		Perimarginal veins	
Laminar size	mesophyll		Major secondary spacing	irregular
Laminar L:W ratio			Variation of secondary angle	uniform
Laminar shape			Major secondary attachment	excurent
Medial symmetry			Intersecondary proximal course	
Base symmetry			Intersecondary length	
Lobation			Intersecondary distal course	
Margin type			Intersecondary vein frequency	
Special margin features		3 ^o	Intercostal tertiary vein fabric	sinuous opposite percurrent
Apex angle			Angle of percurrent tertiaries	obtuse
Apex shape			Vein angle variability	decreasing exmedially
Base angle			Epimedial tertiaries	opposite percurrent
Base shape			Proximal course	obtuse to midvein
Terminal apex features			Distal course	parallel to intercostal tertiary
Surface texture			Exterior tertiary course	looped
Surficial glands		4 ^o	Quaternary vein fabric	alternate percurrent
Sect. III - Teeth		5 ^o	Quintenary vein fabric	regular reticulate
Tooth spacing			Areolation	good development
Number of orders of teeth			FEV branching	
Teeth / cm			FEV termination	
Sinus shape			Marginal Ultimate venation	
Tooth shapes				
Principal vein				
Principal vein termination				
Course of accessory vein				
Features of the tooth apex

Site: AF1407

Mophotype: SJ-94

Specimen #: AF1407-047

Morphotype	Major Plant Group	Organ
SJ-102	Conifer	Leaf
Family	Genus and Species	Exemplar Spec. #
Cupressaceae	<i>Ditaxocladus catenulatus</i>	AF1409C-061

Notes

Thin rod shaped conifer leaves. Expanded joints where stem and leaf meet. Leave opposite.

A

B

Morphotype	Major Plant Group	Organ
SJ-104	Dicot	Seed
Family	Genus and Species	Exemplar Spec. #
	<i>incertae sedis</i>	AF1409C-070

Notes

Small (~0.25 to 0.5 cm across) circular seeds. Seeds borne on long stalk. Seeds are sub opposite to alternate. Thick outer coating present.

1 cm

Site: .

Morph

Speci

Morphotype	Major Plant Group	Organ
SJ-110	Monocot	Leaf
Family	Genus and Species	Exemplar Spec. #
	<i>incertae sedis</i>	AF1404-C2-056

Notes

Thin, grass-like monocot. Approximately 3-4 secondary veins between each primary vein. Venation dense.

Morphotype SJ-111	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1404-C2-032A/B

Notes

Photos A and B are part and counterpart of exemplar.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1 ^o Primary vein framework	basal actinodromous
Leaf arrangement		Naked basal veins	
Leaf organization	simple	Number of basal veins	3
Leaflet organization		Agrophic veins	compound
Leaflet attachment		2 ^o Major 2 ^o vein framework	craspedodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	craspedodromous
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	mesophyll	Major secondary spacing	abruptly increasing proximally
Laminar L:W ratio	2:1	Variation of secondary angle	uniform
Laminar shape	ovate	Major secondary attachment	excurrent
Medial symmetry	symmetrical	Intersecondary proximal course	
Base symmetry	basal extension asymmetrical	Intersecondary length	
Lobation	unlobed	Intersecondary distal course	
Margin type	serrate	Intersecondary vein frequency	
Special margin features		3 ^o Intercostal tertiary vein fabric	convex opposite percurrent
Apex angle	acute	Angle of percurrent tertiaries	obtuse to perpendicular
Apex shape	acuminate	Vein angle variability	increasing proximally
Base angle	reflex	Epimedial tertiaries	opposite percurrent
Base shape	lobate, cordate	Proximal course	perpendicular to midvein
Terminal apex features		Distal course	parallel to intercostal tertiary
Surface texture		Exterior tertiary course	looped
Surficial glands		4 ^o Quaternary vein fabric	opposite percurrent
Sect. III - Teeth		5 ^o Quintenary vein fabric	regular reticulate
Tooth spacing	irregular	Areolation	good development
Number of orders of teeth	1	FEV branching	
Teeth / cm	3 to 4	FEV termination	
Sinus shape	rounded	Marginal Ultimate venation	looped
Tooth shapes	RT/RT, CV/RT		
Principal vein	present		
Principal vein termination	at apex of toothed		
Course of accessory vein			
Features of the tooth apex	mucronate

Morphotype SJ-112	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1404-C2-033A/B

Notes

Leaf has deltoid shape. Photos A and B are part and counterpart of exemplar.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1° Primary vein framework	basal actinodromous
Leaf arrangement		Naked basal veins	
Leaf organization	simple	Number of basal veins	3
Leaflet organization		Agrophic veins	simple
Leaflet attachment		2° Major 2° vein framework	simple brochidodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	simple brochidodromous
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	mesophyll	Major secondary spacing	abruptly increasing proximally
Laminar L:W ratio	1:1	Variation of secondary angle	smoothly increasing proximally
Laminar shape	ovate	Major secondary attachment	excurrent
Medial symmetry	symmetrical	Intersecondary proximal course	
Base symmetry	symmetrical	Intersecondary length	
Lobation	unlobed	Intersecondary distal course	
Margin type	entire	Intersecondary vein frequency	
Special margin features		3° Intercostal tertiary vein fabric	convex opposite percurrent
Apex angle	acute	Angle of percurrent tertiaries	obtuse
Apex shape	acuminate	Vein angle variability	increasing proximally
Base angle	obtuse to reflex	Epimedial tertiaries	opposite percurrent
Base shape	truncate, cordate	Proximal course	perpendicular to midvein
Terminal apex features		Distal course	parallel to intercostal tertiary
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	irregular reticulate
Sect. III - Teeth		5° Quintenary vein fabric	irregular reticulate
Tooth spacing		Areolation	poor development
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Morphotype SJ-113	Major Plant Group Dicot	Organ Leaf
Family Rhamnaceae	Genus and Species <i>"Zizyphus" fibrikillosus</i>	Exemplar Spec. # AF1404-C2-062

Notes

Dense well impressed tertiary veins. Three major basal veins converge at the apex.

Sect. I - Leaf Characters		Sect. II - Venation		
Leaf attachment	petiolate	1°	Primary vein framework	basal acrodromous
Leaf arrangement			Naked basal veins	
Leaf organization	simple		Number of basal veins	3 to 5
Leaflet organization			Agrophic veins	simple
Leaflet attachment		2°	Major 2° vein framework	simple brochidodromous
Petiole features			Interior secondaries	
Features of the blade:			Minor secondary course	simple brochidodromous
Position of lamina attachment	marginal		Perimarginal veins	
Laminar size	mesophyll		Major secondary spacing	abruptly increasing proximally
Laminar L:W ratio			Variation of secondary angle	uniform
Laminar shape	ovate		Major secondary attachment	excurrent
Medial symmetry	symmetrical		Intersecondary proximal course	
Base symmetry	symmetrical		Intersecondary length	
Lobation	unlobed		Intersecondary distal course	
Margin type	entire		Intersecondary vein frequency	
Special margin features		3°	Intercostal tertiary vein fabric	straight opposite percurrent
Apex angle			Angle of percurrent tertiaries	obtuse to perpendicular
Apex shape			Vein angle variability	increasing exmedially
Base angle	obtuse to reflex		Epimedial tertiaries	opposite percurrent
Base shape	rounded, cordate		Proximal course	perpendicular to midvein
Terminal apex features			Distal course	parallel to intercostal tertiary
Surface texture			Exterior tertiary course	looped
Surficial glands		4°	Quaternary vein fabric	opposite percurrent
Sect. III - Teeth		5°	Quintenary vein fabric	regular reticulate
Tooth spacing			Areolation	good development
Number of orders of teeth			FEV branching	
Teeth / cm			FEV termination	
Sinus shape			Marginal Ultimate venation	looped
Tooth shapes				
Principal vein				
Principal vein termination				
Course of accessory vein				
Features of the tooth apex				

A

B

Morphotype	Major Plant Group	Organ
SJ-114	Dicot	Flower
Family	Genus and Species	Exemplar Spec. #
	<i>incertae sedis</i>	AF1404-C2-065

Notes

Five petaled flower approximately 4-5 mm in diameter. Petals are relatively small, rounded.

Morphotype SJ-119	Major Plant Group Dicot	Organ Leaf
Family	Genus and Species <i>incertae sedis</i>	Exemplar Spec. # AF1404-C2-064

Notes

First 2-3 pairs of secondary veins nearly perpendicular to midvein. Secondary veins opposite at base and alternate distally.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1° Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization	simple	Number of basal veins	1
Leaflet organization		Agrophic veins	
Leaflet attachment		2° Major 2° vein framework	eucampto- to brochido- distally
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	mesophyll	Major secondary spacing	decreasing proximally
Laminar L:W ratio	2:1	Variation of secondary angle	smoothly increasing proximally
Laminar shape	ovate to elliptic	Major secondary attachment	excurrent
Medial symmetry	symmetrical	Intersecondary proximal course	
Base symmetry	symmetrical	Intersecondary length	
Lobation	unlobed	Intersecondary distal course	
Margin type	entire	Intersecondary vein frequency	
Special margin features		3° Intercostal tertiary vein fabric	straight opposite percurrent
Apex angle	acute	Angle of percurrent tertiaries	obtuse to perpendicular
Apex shape	straight, acuminate	Vein angle variability	increasing exmedially
Base angle	obtuse	Epimedial tertiaries	opposite percurrent
Base shape	rounded	Proximal course	perpendicular to midvein
Terminal apex features		Distal course	parallel to intercostal tertiary
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	
Sect. III - Teeth		5° Quintenary vein fabric	
Tooth spacing		Areolation	
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex			

27
↓

Site: AF1404-L
Morphotype: JJ-119
Specimen #: AF1404-L-064

Morphotype SJ-151	Major Plant Group Dicot	Organ Leaf
Family Lauraceae	Genus and Species <i>"Artocarpus" lessigiana</i>	Exemplar Spec. # AF1409D-111

Notes

Large leaf. Usually with multiple lobes. Single lobes frequently found.

Sect. I - Leaf Characters		Sect. II - Venation	
Leaf attachment	petiolate	1° Primary vein framework	pinnate
Leaf arrangement		Naked basal veins	
Leaf organization	simple	Number of basal veins	1
Leaflet organization		Agrophic veins	
Leaflet attachment		2° Major 2° vein framework	simple brochidodromous
Petiole features		Interior secondaries	
Features of the blade:		Minor secondary course	
Position of lamina attachment	marginal	Perimarginal veins	
Laminar size	meso- to megaphyll	Major secondary spacing	decreasing proximally
Laminar L:W ratio		Variation of secondary angle	inconsistent
Laminar shape		Major secondary attachment	excurrent
Medial symmetry	symmetrical	Intersecondary proximal course	parallel to major secondary
Base symmetry	symmetrical	Intersecondary length	< 50% major secondary
Lobation	pinnately lobed	Intersecondary distal course	basiflexed
Margin type	entire	Intersecondary vein frequency	<1 per intercostal area
Special margin features		3° Intercostal tertiary vein fabric	mixed percurrent
Apex angle	acute	Angle of percurrent tertiaries	obtuse
Apex shape	straight	Vein angle variability	inconsistent
Base angle		Epimedial tertiaries	opposite percurrent
Base shape		Proximal course	perpendicular to midvein
Terminal apex features		Distal course	reticulate
Surface texture		Exterior tertiary course	looped
Surficial glands		4° Quaternary vein fabric	irregular reticulate
Sect. III - Teeth		5° Quintenary vein fabric	irregular reticulate
Tooth spacing		Areolation	moderate development
Number of orders of teeth		FEV branching	
Teeth / cm		FEV termination	
Sinus shape		Marginal Ultimate venation	looped
Tooth shapes			
Principal vein			
Principal vein termination			
Course of accessory vein			
Features of the tooth apex

Supplementary Table 1: Systematic list of megafloral morphotypes from the San Juan Basin. Aff = affinity in larger taxonomic category, EQU = equisetopsida, PTE = pteridophyte, CON = conifer, MON = monocotyledonous angiosperm, DIC = dicotyledonous angiosperm,

Aff	Order	Family	Organ	Margin	Taxonomic name (morphotype number)
CON	Pinales	Cupressaceae	Leaf	-	<i>Cupressinocladus interruptus</i> (SJ-68)
CON	Pinales	Cupressaceae	Leaf	-	<i>Ditaxocladus catenulatus</i> (SJ-102)
EQU	Equisetales	Equisetaceae	Leaf	-	<i>Equisetum</i> sp. (SJ-64)
EQU	Equisetales	Equisetaceae	Seed/Fruit	-	<i>Equisetum</i> sp. (SJ-67)
LYC	Selaginellales	Selaginellaceae	Leaf	-	<i>Selginella</i> sp. (SJ-59)
MON	Arecales	Areaceae	Seed/Fruit	-	SJ-70
MON	Alismatales	Araceae	Leaf	-	<i>Limnobiophyllum scutatum</i> (SJ-62)
MON	Zingiberales	Zingiberaceae	Leaf	-	SJ-65
MON	Incertae Sedis	-	Leaf	-	SJ-60
MON	Incertae Sedis	-	Leaf	-	SJ-79
MON	Incertae Sedis	-	Leaf	-	SJ-86
MON	Incertae Sedis	-	Leaf	-	SJ-92
MON	Incertae Sedis	-	Leaf	-	SJ-110
PTE	Polypodiales	Onocleaceae	Leaf	-	<i>Onoclea sensibilis</i> (SJ-56)
PTE	Polypodiales	Incertae Sedis	Leaf	-	SJ-61
PTE	Schizaeales	Anemiaceae	Leaf	-	" <i>Anemia</i> " sp. (SJ-57)
DIC	Cornales	Nyssaceae	Leaf	T	<i>Browniea serrata</i> (SJ-78)
DIC	Laurales	Lauraceae	Leaf	U	" <i>Artocarpus</i> " <i>lessigiana</i> (SJ-151)
DIC	Nymphaeales	Nymphaeaceae	Leaf	U	<i>Paranymphaea crassifolia</i> (SJ-51)
DIC	Oxidales	Oxidalaceae	Leaf	U	<i>Averrhoites affinis</i> (SJ-46)
DIC	Proteales	Platanaceae	Leaf	T	<i>Platanites raynoldsii</i> (SJ-36)
DIC	Proteales	Platanaceae	Leaf	T	<i>Platanites marginata</i> (SJ-71)
DIC	Rosales?	Rhamnaceae?	Leaf	U	" <i>Rhamnus</i> " <i>goldiana</i> (SJ-80)
DIC	Rosales?	Rhamnaceae?	Leaf	U	<i>Zizyphus fibrillosus</i> (SJ-113)
DIC	Saxifragales	Cercidiphyllaceae	Leaf	T	" <i>Populus</i> " <i>nebrascensis</i> (SJ-13)
DIC	Incertae Sedis	-	Leaf	U	SJ-14
DIC	Incertae Sedis	-	Leaf	U	SJ-25
DIC	Incertae Sedis	-	Leaf	U	SJ-28
DIC	Incertae Sedis	-	Leaf	U	SJ-48
DIC	Incertae Sedis	-	Leaf	U	SJ-50
DIC	Incertae Sedis	-	Leaf	U	SJ-53
DIC	Incertae Sedis	-	Seed/Fruit	-	SJ-54
DIC	Incertae Sedis	-	Leaf	U	SJ-55
DIC	Incertae Sedis	-	Leaf	T	SJ-58
DIC	Incertae Sedis	-	Leaf	U	SJ-63
DIC	Incertae Sedis	-	Leaf	U	SJ-66
DIC	Incertae Sedis	-	Leaf	U	SJ-69
DIC	Incertae Sedis	-	Leaf	U	SJ-72
DIC	Incertae Sedis	-	Leaf	U	SJ-73
DIC	Incertae Sedis	-	Leaf	T	SJ-76
DIC	Incertae Sedis	-	Leaf	T	SJ-77
DIC	Incertae Sedis	-	Leaf	U	SJ-81
DIC	Incertae Sedis	-	Leaf	U	SJ-82
DIC	Incertae Sedis	-	Leaf	U	<i>Dicotylophyllum horsecreekium</i> (SJ-83)
DIC	Incertae Sedis	-	Leaf	U	SJ-88
DIC	Incertae Sedis	-	Leaf	U	SJ-89
DIC	Incertae Sedis	-	Leaf	U	SJ-90
DIC	Incertae Sedis	-	Seed/Fruit	-	SJ-91
DIC	Incertae Sedis	-	Leaf	U	SJ-93
DIC	Incertae Sedis	-	Leaf	U	SJ-94
DIC	Incertae Sedis	-	Seed/Fruit	-	SJ-104
DIC	Incertae Sedis	-	Leaf	T	SJ-111
DIC	Incertae Sedis	-	Leaf	U	SJ-112
DIC	Incertae Sedis	-	Flower	-	SJ-114
DIC	Incertae Sedis	-	Leaf	U	SJ-119

Supplementary Table 2 - Stratigraphic position, depositional facies, location, and morphotype tallies for all floral collections. Affinity = major plant group (DIC = dicot angiosperms, MON = monocot angiosperms, PTE = ferns, EQU = horsetails, LYC = lycophytes, CON = conifers). Margin = dicot margin type (T = toothed, U = untoothed). Field tally = number of specimens tallied in the field for census collections. Lab tally = number of specimens tallied in the lab from voucher collections.

Locality AF1404

Stratigraphic position above

Naashoibito-Ojo Alamo 6.0

Contact (m)

Depositional Facies Overbank/Crevasse splay

Location (UTM) 12 S 0768154 4023714

Morphotype	Name (if known)	Affinity	Margin	Field Tally	Lab Tally	Total
SJ-036	<i>Platanites raynoldsii</i>	DIC	T	92	17	109
SJ-046	<i>Averrhoites affinis</i>	DIC	U	27	2	29
SJ-048		DIC	U	0	1	1
SJ-051	<i>Paranymphea crassifolia</i>	DIC	U	0	3	3
SJ-060		MON	-	2	0	2
SJ-064	<i>Equisetum sp.</i>	EQU	-	2	0	2
SJ-071	<i>Platanites marginata</i>	DIC	T	86	2	88
SJ-077		DIC	T	5	2	7
SJ-078	<i>Brownea serrata</i>	DIC	T	14	0	14
SJ-082		DIC	U	21	1	22
SJ-086	<i>Sabalites sp.</i>	MON	-	2	1	3
SJ-090		DIC	U	3	0	3
SJ-102	<i>Ditaxocladus catenulata</i>	CON	-	82	0	82
SJ-104		DIC	-	1	0	1
SJ-110		MON	-	5	0	5
SJ-111		DIC	T	1	0	1
SJ-112		DIC	U	5	0	5
SJ-113	<i>Zizyphus fibrillosus</i>	DIC	U	4	0	4
SJ-114		DIC	-	1	0	1
SJ-119		DIC	U	1	0	1
Total Morphotypes	20			354	29	383

Locality AF1409

Stratigraphic position above

Naashoibito-Ojo Alamo 11.5

Contact (m)

Depositional Facies Overbank/Crevasse splay

Location (UTM) 12 S 0767253 4023914

Morphotype	Name (if known)	Affinity	Margin	Field Tally	Lab Tally	Total
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SJ-036	<i>Platanites raynoldsii</i>	DIC	T	0	6	6
SJ-051	<i>Paranymphea crassifolia</i>	DIC	U	0	1	1
SJ-078	<i>Brownea serrata</i>	DIC	T	0	1	1
SJ-079	<i>Sabalites</i> sp.	MON	-	0	1	1
SJ-080	" <i>Rhamnus</i> " <i>goldiana</i>	DIC	U	0	1	1
SJ-082		DIC	U	0	5	5
Total Morphotypes				0	15	15

Locality AF1409B
Stratigraphic position above
Naashoibito-Ojo Alamo 11.5
Contact (m)
Depositional Facies Overbank/Crevasse splay
Location (UTM) 12 S 0767154 4023382

Morphotype	Name (if known)	Affinity	Margin	Field Tally	Lab Tally	Total
SJ-013	" <i>Populus</i> " <i>nebrascensis</i>	DIC	T	0	1	1
SJ-036	<i>Platanites raynoldsii</i>	DIC	T	0	6	6
SJ-046	<i>Averrhoites affinis</i>	DIC	U	0	3	3
SJ-061		PTE	-	0	3	3
SJ-064	<i>Equisetum</i> sp.	EQU	-	0	2	2
SJ-071	<i>Platanites marginata</i>	DIC	T	0	1	1
SJ-080	" <i>Rhamnus</i> " <i>goldiana</i>	DIC	U	0	3	3
SJ-088		DIC	U	0	1	1
SJ-102	<i>Ditaxocladus catenulata</i>	CON	-	0	1	1
SJ-151	" <i>Artocarpus</i> " <i>lessigiana</i>	DIC	U	0	2	2
Total Morphotypes				0	23	23

Locality AF1409C
Stratigraphic position above
Naashoibito-Ojo Alamo 11.5
Contact (m)
Depositional Facies Overbank/Crevasse splay
Location (UTM) 12 S 0767154 4023382

Morphotype	Name (if known)	Affinity	Margin	Field Tally	Lab Tally	Total
SJ-036	<i>Platanites raynoldsii</i>	DIC	T	0	20	20
SJ-046	<i>Averrhoites affinis</i>	DIC	U	0	7	7
SJ-051	<i>Paranymphea crassifolia</i>	DIC	U	0	2	2
SJ-062	<i>Limnobiophyllum scutatum</i>	MON	-	0	1	1
SJ-064	<i>Equisetum</i> sp.	EQU	-	0	3	3
SJ-068	<i>Cupressinocladus interruptis</i>	CON	-	0	27	27
SJ-071	<i>Platanites marginata</i>	DIC	T	0	1	1
SJ-077		DIC	T	0	4	4
SJ-080	" <i>Rhamnus</i> " <i>goldiana</i>	DIC	U	0	5	5

SJ-082		DIC	U	0	11	11
SJ-088		DIC	U	0	3	3
SJ-093		DIC	U	0	1	1
SJ-102	<i>Ditaxocladus catenulata</i>	CON	-	0	10	10
SJ-104		DIC	-	0	4	4
Total Morphotypes				0	99	99

Locality AF1409D
Stratigraphic position above
Naashoibito-Ojo Alamo 11.5
Contact (m)
Depositional Facies Overbank/Crevasse splay
Location (UTM) 12 S 0767140 4023368

Morphotype	Name (if known)	Affinity	Margin	Field Tally	Lab Tally	Total
SJ-036	<i>Platanites raynoldsii</i>	DIC	T	31	0	31
SJ-046	<i>Averrhoites affinis</i>	DIC	U	54	0	54
SJ-051	<i>Paranymphea crassifolia</i>	DIC	U	6	0	6
SJ-056	<i>Onoclea sensibilis</i>	PTE	-	2	0	2
SJ-071	<i>Platanites marginata</i>	DIC	T	32	0	32
SJ-072		DIC	U	1	0	1
SJ-073		DIC	U	1	0	1
SJ-076		DIC	T	19	0	19
SJ-077		DIC	T	22	0	22
SJ-078	<i>Browneia serrata</i>	DIC	T	13	0	13
SJ-079		MON	-	10	0	10
SJ-080	<i>"Rhamnus" goldiana</i>	DIC	U	15	0	15
SJ-081		DIC	T	0	1	1
SJ-082		DIC	U	92	0	92
SJ-083		DIC	-	4	0	4
SJ-086	<i>Sabalites sp.</i>	MON	-	2	0	2
SJ-088		DIC	T	3	0	3
SJ-089		DIC	U	1	0	1
SJ-090		DIC	U	1	0	1
SJ-091		DIC	-	2	0	2
SJ-151	<i>"Artocarpus" lessigiana</i>	DIC	U	1	0	1
Total Morphotypes				312	1	313

Locality AF1403
Stratigraphic position above
Naashoibito-Ojo Alamo 11.9
Contact (m)
Depositional Facies Pond/Carbonaceous Shale
Location (UTM) 12 S 0768334 4023474

Morphotype	Name (if known)	Affinity	Margin	Field Tally	Lab Tally	Total
SJ-046	<i>Averrhoites affinis</i>	DIC	U	0	2	2
SJ-064	<i>Equisetum sp.</i>	EQU	-	0	10	10
SJ-065		MON	-	0	1	1
Total Morphotypes	3			0	13	13

Locality AF1407
Stratigraphic position above
Naashoibito-Ojo Alamo 12.5
Contact (m)
Depositional Facies Pond/Carbonaceous Shale
Location (UTM) 12 S 0769150 4023648

Morphotype	Name (if known)	Affinity	Margin	Field Tally	Lab Tally	Total
SJ-013	<i>"Populus" nebrascensis</i>	DIC	T	0	1	1
SJ-014		DIC	U	0	1	1
SJ-018		DIC	T	0	1	1
SJ-036	<i>Platanites raynoldsii</i>	DIC	T	0	7	7
SJ-046	<i>Averrhoites affinis</i>	DIC	U	594	176	770
SJ-050		DIC	U	57	2	59
SJ-051	<i>Paranymphea crassifolia</i>	DIC	U	0	5	5
SJ-053		DIC	U	0	1	1
SJ-054		DIC	-	1	0	1
SJ-055		DIC	U	15	1	16
SJ-056	<i>Onoclea sensibilis</i>	PTE	-	1	1	2
SJ-057	<i>"Anemia" sp.</i>	PTE	-	1	6	7
SJ-058		DIC	U	2	0	2
SJ-059	<i>Selaginella sp.</i>	LYC	-	2	0	2
SJ-060		MON	-	2	6	8
SJ-062	<i>Limnobiophyllum scutatum</i>	MON	-	3	0	3
SJ-063		DIC	U	2	0	2
SJ-065		MON	-	15	2	17
SJ-066		DIC	U	1	0	1
SJ-068	<i>Cupressinocladus interruptis</i>	CON	-	0	2	2
SJ-071	<i>Platanites marginata</i>	DIC	T	0	1	1
SJ-078	<i>Brownea serrata</i>	DIC	T	15	8	23
SJ-082		DIC	U	0	1	1
SJ-093		DIC	U	0	2	2
SJ-094		DIC	U	0	1	1
Total Morphotypes	24			711	225	936

Locality AF1407B
Stratigraphic position above
Naashoibito-Ojo Alamo 12.5
Contact (m)

Depositional Facies
Location (UTM)

Pond/Carbonaceous Shale
13S 0230696 4023960

Morphotype	Name (if known)	Affinity	Margin	Field Tally	Lab Tally	Total
SJ-025		DIC	U	5	0	5
SJ-028		DIC	T	2	0	2
SJ-036	<i>Platanites raynoldsii</i>	DIC	T	65	2	67
SJ-046	<i>Averrhoites affinis</i>	DIC	U	131	5	136
SJ-050		DIC	U	8	0	8
SJ-056	<i>Onoclea sensibilis</i>	PTE	-	2	0	2
SJ-057	"Anemia" sp.	PTE	-	1	0	1
SJ-059	<i>Selaginella</i> sp.	LYC	-	17	0	17
SJ-060		DIC	U	38	0	38
SJ-062	<i>Limnobiophyllum scutatum</i>	MON	-	1	1	2
SJ-064	<i>Equisetum</i> sp.	EQU	-	17	0	17
SJ-065				17	1	18
SJ-067		DIC	U	1	0	1
SJ-068	<i>Cupressinocladus interruptis</i>	CON	-	13	2	15
SJ-069		MON	-	2	0	2
SJ-070				1	0	1
SJ-078	<i>Browneia serrata</i>	DIC	T	3	0	3
SJ-092		MON	-	0	2	2
Total Morphotypes	18			324	13	337

Locality DP1301
Stratigraphic position above
Naashoibito-Ojo Alamo 13.0
Contact (m)
Depositional Facies Pond/Carbonaceous Shale
Location (UTM) 12S 0768124 4024321

Morphotype	Name (if known)	Affinity	Margin	Field Tally	Lab Tally	Total
SJ-046	<i>Averrhoites affinis</i>	DIC	U	0	31	31
SJ-050		DIC	U	0	1	1
SJ-057	"Anemia" sp.	PTE	-	0	2	2
SJ-062	<i>Limnobiophyllum scutatum</i>	MON	-	0	1	1
SJ-064	<i>Equisetum</i> sp.	EQU	-	0	1	1
SJ-065		MON	-	0	4	4
Total Morphotypes	3			0	40	40

Locality DP1301B
Stratigraphic position above
Naashoibito-Ojo Alamo 13.0
Contact (m)
Depositional Facies Pond/Carbonaceous Shale

Location (UTM)

12S 0768124 4024321

Morphotype	Name (if known)	Affinity	Margin	Field Tally	Lab Tally	Total
SJ-014		DIC	U	2	0	2
SJ-036	<i>Platanites raynoldsii</i>	DIC	T	11	0	11
SJ-046	<i>Averrhoites affinis</i>	DIC	U	561	0	561
SJ-048		DIC	U	2	0	2
SJ-050		DIC	U	10	0	10
SJ-051	<i>Paranymphaea crassfolia</i>	DIC	U	2	0	2
SJ-056	<i>Onoclea sensibilis</i>	PTE	-	1	0	1
SJ-060		MON	-	4	0	4
SJ-062	<i>Limnobiophyllum scutatum</i>	MON	-	1	0	1
SJ-065		MON	-	2	0	2
SJ-068	<i>Cupressinocladus interruptis</i>	CON	-	1	0	1
SJ-078	<i>Browneia serrata</i>	DIC	T	3	0	3
SJ-089		DIC	U	1	0	1
Total Morphotypes	13			601	0	601

Locality

AF1402

Stratigraphic position above

Naashoibito-Ojo Alamo

14.0

Contact (m)

Depositional Facies

Pond/Carbonaceous Shale

Location (UTM)

12S 0768330 4024210

Morphotype	Name (if known)	Affinity	Margin	Field Tally	Lab Tally	Total
SJ-036	<i>Platanites raynoldsii</i>	DIC	T	5	0	5
SJ-046	<i>Averrhoites affinis</i>	DIC	U	476	0	476
SJ-050		DIC	U	1	0	1
SJ-055		DIC	U	1	0	1
SJ-056	<i>Onoclea sensibilis</i>	PTE	-	2	0	2
SJ-057	<i>"Anemia" sp.</i>	PTE	-	111	0	111
SJ-059	<i>Selaginella sp.</i>	LYC	-	2	0	2
SJ-060		MON	-	33	0	33
SJ-061		PTE	-	3	0	3
SJ-062	<i>Limnobiophyllum scutatum</i>	MON	-	4	0	4
Total Morphotypes	10			638	0	638

Locality

AF1415

Stratigraphic position above

Naashoibito-Ojo Alamo

14.7

Contact (m)

Depositional Facies

Pond/Carbonaceous Shale

Location (UTM)

12S 0767362 4024540

Morphotype	Name (if known)	Affinity	Margin	Field Tally	Lab Tally	Total
SJ-036	<i>Platanites raynoldsii</i>	DIC	T	0	7	7
SJ-046	<i>Averrhoites affinis</i>	DIC	U	0	1	1
SJ-051	<i>Paranymphea crassifolia</i>	DIC	U	0	1	1
SJ-071	<i>Platanites marginata</i>	DIC	T	0	1	1
SJ-079	<i>Sabalites sp.</i>	MON	-	0	1	1
SJ-104		DIC	-	0	1	1
Total Morphotypes	6			0	12	12

Supplementary Table 3: Total census data from the San Juan Basin. Aff = affinity in larger taxonomic category, EQU = equisetopsida, PTE = pteridophyte, CON = conifer, MON = monocotyledonous angiosperm, DIC = dicotyledonous angiosperm, Margin = dicotyledonous

Plant Group	Organ	Margin	Morphotype	DP1301/01B	AF1402	AF1404	AF1407	AF1407B	AF1409D	Total
DIC	Leaf	Untoothed	SJ-14	2	0	0	0	0	0	2
DIC	Leaf	Untoothed	SJ-25	0	0	0	0	5	0	5
DIC	Leaf	Untoothed	SJ-28	0	0	0	0	2	0	2
DIC	Leaf	Toothed	SJ-36	11	5	92	0	65	31	204
DIC	Leaf	Untoothed	SJ-46	561	476	27	594	131	54	1843
DIC	Leaf	Untoothed	SJ-48	2	0	0	0	0	0	2
DIC	Leaf	Untoothed	SJ-50	10	1	0	57	8	0	76
DIC	Leaf	Untoothed	SJ-51	2	0	0	0	0	6	8
DIC	Seed/Fruit	N/A	SJ-54	0	0	0	1	0	0	1
DIC	Leaf	Untoothed	SJ-55	0	1	0	15	0	0	16
PTE	Leaf	N/A	SJ-56	1	2	0	1	2	1	7
PTE	Leaf	N/A	SJ-57	0	111	0	1	1	0	113
DIC	Leaf	Toothed	SJ-58	0	0	0	2	0	0	2
LYC	Leaf	N/A	SJ-59	0	2	0	2	17	0	21
MON	Leaf	N/A	SJ-60	4	33	2	2	38	0	79
PTE	Leaf	N/A	SJ-61	0	3	0	0	0	0	3
MON	Leaf	N/A	SJ-62	1	4	0	3	1	0	9
DIC	Leaf	Untoothed	SJ-63	0	0	0	2	0	0	2
EQU	Leaf	N/A	SJ-64	0	0	2	0	17	0	19
MON	Leaf	N/A	SJ-65	2	0	0	15	18	0	35
DIC	Leaf	Untoothed	SJ-66	0	0	0	1	0	0	1
EQU	Seed/Fruit	N/A	SJ-67	0	0	0	0	1	0	1
CON	Leaf	N/A	SJ-68	1	0	0	0	13	0	14
DIC	Leaf	Untoothed	SJ-69	0	0	0	0	2	0	2
MON	Seed/Fruit	N/A	SJ-70	0	0	0	0	1	0	1
DIC	Leaf	Toothed	SJ-71	0	0	86	0	0	32	118
DIC	Leaf	Untoothed	SJ-72	0	0	0	0	0	1	1
DIC	Leaf	Untoothed	SJ-73	0	0	0	0	0	1	1
DIC	Leaf	Toothed	SJ-76	0	0	0	0	0	19	19
DIC	Leaf	Toothed	SJ-77	0	0	5	0	0	22	27
DIC	Leaf	Toothed	SJ-78	3	0	14	15	3	13	48
MON	Leaf	N/A	SJ-79	0	0	0	0	0	10	10
DIC	Leaf	Untoothed	SJ-80	0	0	0	0	0	15	15
DIC	Leaf	Untoothed	SJ-81	0	0	0	0	0	1	1
DIC	Leaf	Untoothed	SJ-82	0	0	21	0	0	92	113
DIC	Leaf	Untoothed	SJ-83	0	0	0	0	0	4	4
MON	Leaf	N/A	SJ-86	0	0	2	0	0	2	4
DIC	Leaf	Untoothed	SJ-88	0	0	0	0	0	3	3
DIC	Leaf	Untoothed	SJ-89	1	0	0	0	0	1	2
DIC	Leaf	Untoothed	SJ-90	0	0	3	0	0	1	4
DIC	Seed/Fruit	N/A	SJ-91	0	0	0	0	0	2	2
CON	Leaf	N/A	SJ-102	0	0	82	0	0	0	82
DIC	Seed/Fruit	N/A	SJ-104	0	0	1	0	0	0	1
MON	Leaf	N/A	SJ-110	0	0	5	0	0	0	5
DIC	Leaf	Toothed	SJ-111	0	0	1	0	0	0	1
DIC	Leaf	Untoothed	SJ-112	0	0	5	0	0	0	5
DIC	Leaf	Untoothed	SJ-113	0	0	4	0	0	0	4
DIC	Flower	N/A	SJ-114	0	0	1	0	0	0	1
DIC	Leaf	Untoothed	SJ-119	0	0	1	0	0	0	1
DIC	Leaf	Untoothed	SJ-151	0	0	0	0	0	1	1

Sunk Morphotypes	New Morphotype
SJ-06	SJ-46
SJ-38	SJ-36
SJ-47	SJ-51
SJ-49	SJ-14
SJ-52	SJ-78
SJ-74	---
SJ-75	SJ-78
SJ-84	---
SJ-85	---
SJ-87	---

Supplementary Table 4: Total presence/absence data from the San Juan Basin. Aff = affinity in larger taxonomic category, EQU = equisetopsida, PTE = pteridophyte, CON = conifer, MON = monocotyledonous angiosperm, DIC = dicotyledonous angiosperm, Margin = dicotyledonous angiosperm margin (T = toothed, E = entire)

[illegible]

DIC	Leaf	Untoothed	SJ-90	0	0	0	0	1	0	0	0	0	0	1	0
DIC	Seed/Fruit	N/A	SJ-91	0	0	0	0	0	0	0	0	0	0	1	0
MON	Leaf	N/A	SJ-92	0	0	0	0	0	0	1	0	0	0	0	0
DIC	Leaf	Untoothed	SJ-93	0	0	0	0	0	1	0	0	0	1	0	0
DIC	Leaf	Untoothed	SJ-94	0	0	0	0	0	1	0	0	0	0	0	0
CON	Leaf	N/A	SJ-102	0	0	0	0	1	0	0	0	1	1	0	0
DIC	Seed/Fruit	N/A	SJ-104	0	0	0	0	1	0	0	0	0	1	0	1
MON	Leaf	N/A	SJ-110	0	0	0	0	1	0	0	0	0	0	0	0
DIC	Leaf	Toothed	SJ-111	0	0	0	0	1	0	0	0	0	0	0	0
DIC	Leaf	Untoothed	SJ-112	0	0	0	0	1	0	0	0	0	0	0	0
DIC	Leaf	Untoothed	SJ-113	0	0	0	0	1	0	0	0	0	0	0	0
DIC	Flower	N/A	SJ-114	0	0	0	0	1	0	0	0	0	0	0	0
DIC	Leaf	Untoothed	SJ-119	0	0	0	0	1	0	0	0	0	0	0	0
DIC	Leaf	Untoothed	SJ-151	0	0	0	0	0	0	0	0	1	0	1	0

Sunk Morphotypes	New Morphotype
SJ-06	SJ-46
SJ-32	SJ-36
SJ-38	SJ-36
SJ-47	SJ-51
SJ-49	SJ-14
SJ-52	SJ-78
SJ-74	---
SJ-75	SJ-78
SJ-84	---
SJ-85	---
SJ-87	---

Supplementary Table 5 - Total Ojo Alamo Sandstone and facies mean physiognomic variables using the DiLP paleoclimate calculations. Percent untoothed for all sites/facies generated using the entire flora, including specimens not processed digitally for DiLP measurements. See Peppe et al. 2011 for definitions of variables and abbreviations.

Site/ Facies	Percent untoothed	#primary teeth	#secondary teeth	#teeth	Tooth area (cm ²)	Inferred leaf area (cm ²)	Feret diameter ratio	Perimeter ratio	#teeth/ perimeter (cm ⁻¹)	#teeth/ internal perimeter (cm ⁻¹)	#teeth/ blade area (cm ⁻²)	tooth area/ perimeter (cm)	tooth area/ internal perimeter (cm)	tooth area/ blade area	average tooth area (cm ²)
Total Ojo Alamo	79.41	11.681	2.167	11.903	0.095	24.151	0.709	1.078	1.140	1.251	1.027	0.009	0.010	0.008	0.010
Pond Flora	80.00	9.500	2.000	9.833	0.087	18.824	0.660	1.084	1.768	1.946	1.797	0.013	0.014	0.013	0.011
Overbank Flora	73.00	12.546	2.167	12.752	0.104	31.644	0.740	1.083	1.143	1.264	0.008	0.010	0.011	0.008	0.011

Supplementary Table 6 - Measured leaf physiognomy values for all measureable specimens/morphotypes. See Supplementary Table 1 for taxonomic assignment of morphotypes. See Peppe et al. 2011 for definitions of variables and abbreviations.

Site	Morphotype	Specimen #	Margin (0 - toothed; 1 - untoothed)	Petiole width (cm)	Petiole area (cm ²)	Inferred blade area (cm ²)	Raw blade area (cm ²)	Raw perimeter (cm)	Major length (cm)	Length of cut perimeter (cm)	Raw internal perimeter (cm)	Raw internal blade area (cm ²)	#primary teeth	#secondary teeth	Tooth area (cm ²)
AF1407	SJ-14	AF1407-076	1			7.946			8.763						
AF1404-C2	SJ-36	AF1404-C2-054	0	0.187	0.108	32.642	13.934	23.892	7.41	14.16	23.208	13.85	4		0.092
AF1404-C2	SJ-36	AF1404-C2-055	0	0.095	0.056	6.91	3.268	11.774	4.407	6.512	11.64	3.245	8		0.032
AF1407	SJ-36	AF1407-096B	0			34.488	14.796	31.842	9.738	16.707	30.972	14.672	5	2	0.136
AF1407B-C	SJ-36	AF1407B-C-022	0			7.356	4.029	16.096	4.464	9.56	15.225	3.964	10		0.077
AF1407B-C	SJ-36	AF1407B-C-023	0			6.472	3.114	13.673	4.249	6.51	12.63	3.038	14		0.093
AF1409C	SJ-36	AF1409C-042	0	0.127	0.035	24.769	19.624	32.686	7.471	12.60	30.506	19.399	13		0.226012
AF1409D	SJ-36	AF1409D-012	0			18.734	9.595	27.553	6.239	19.25	26.535	9.424	9		0.181
AF1409D	SJ-36	AF1409D-013	0				15.94	25.496		15.73	23.834	15.728	10		0.108
AF1409D	SJ-36	AF1409D-015	0				17.711	32.52		21.73	31.61	17.516	2	2	0.203
AF1409D	SJ-36	AF1409D-038	0				26.32	45.36		30.15	43.996	26.12	19		0.258
AF1409D	SJ-36	AF1409D-051	0			28.42	8.09	21.63	7.52	13.84	21.403	8.00	2		0.046
AF1409D	SJ-36	AF1409D-053	0				22.90	40.62		31.16	39.96	22.81	5		0.142
AF1402	SJ-46	AF1402-008	1			7.33			6.22						
AF1404-C2	SJ-46	AF1404-C2-036B	1			31.50			11.22						
AF1404-C2	SJ-46	AF1404-C2-038	1	0.114	0.022	14.747			7.654						
AF1407	SJ-46	AF1407-002	1			5.315			5.819						
AF1407	SJ-46	AF1407-003	1	0.067		12.692			7.514						
AF1407	SJ-46	AF1407-006	1	0.117	0.026	3.783			4.393						
AF1407	SJ-46	AF1407-010	1			4.398			3.946						
AF1407	SJ-46	AF1407-017	1			4.286			3.332						
AF1407	SJ-46	AF1407-018	1			14.54			9.625						
AF1407	SJ-46	AF1407-020	1			14.197			6.821						
AF1407	SJ-46	AF1407-024	1	0.066		10.036			6.391						
AF1407	SJ-46	AF1407-026A	1			31.064			10.136						
AF1407	SJ-46	AF1407-037	1			37.732			10.527						
AF1407	SJ-46	AF1407-040	1			20.249			8.153						
AF1407	SJ-46	AF1407-049	1	0.032		4.91			5.079						
AF1407	SJ-46	AF1407-053	1	0.068	0.005	2.943			3.985						
AF1407	SJ-46	AF1407-056	1			22.943			8.68						
AF1407	SJ-46	AF1407-057	1			13.563			6.697						
AF1407	SJ-46	AF1407-058	1	0.096		13.066			6.091						
AF1407	SJ-46	AF1407-059	1	0.12		12.115			6.519						
AF1409C	SJ-46	AF1409C-021A	1			7.322			6.846						
AF1409C	SJ-46	AF1409C-022A/B	1			7.959			6.565						
AF1409D	SJ-46	AF1409D-020	1			16.496			6.582						
DP1301	SJ-46	DP1301-001	1			9.83			6.492						
DP1301	SJ-46	DP1301-002	1			12.83			6.451						
DP1301	SJ-46	DP1301-003	1			11.018			5.93						
DP1301	SJ-46	DP1301-004	1			13.02			6.53						
DP1301	SJ-46	DP1301-006	1	0.029		4.18			3.23						
DP1301B	SJ-46	DP1301B-001-A	1			10.64			6.85						
DP1301B	SJ-46	DP1301B-001-B	1	0.081		19.24			7.56						
DP1301B	SJ-46	DP1301B-002A	1			1.82			3.65						

DP1301B	SJ-46	DP1301B-003	1	0.082		15.42	7.46
DP1301B	SJ-46	DP1301B-004	1			4.77	4.10
DP1301B	SJ-46	DP1301B-007	1	0.075	0.02	14.14	6.36
DP1301B	SJ-46	DP1301B-008-A	1	0.048		5.58	4.86
DP1301B	SJ-46	DP1301B-008-B	1			9.06	4.86
DP1301B	SJ-46	DP1301B-009-A	1			2.09	2.50
DP1301B	SJ-46	DP1301B-009-B	1			13.91	6.28
DP1301B	SJ-46	DP1301B-010	1	0.122	0.028	8.41	5.24
DP1301B	SJ-46	DP1301B-011	1			17.07	7.50
DP1301B	SJ-46	DP1301B-012A-A	1	0.119		11.87	5.60
DP1301B	SJ-46	DP1301B-012A-B	1			9.67	6.11
DP1301B	SJ-46	DP1301B-012A-C	1			9.15	5.26
DP1301B	SJ-46	DP1301B-012A-D	1	0.115		7.63	5.33
DP1301B	SJ-46	DP1301B-012A-E	1			7.52	4.78
DP1301B	SJ-46	DP1301B-012B-A	1	0.05		8.05	5.91
DP1301B	SJ-46	DP1301B-012B-B	1			10.07	5.97
DP1301B	SJ-46	DP1301B-012B-C	1			6.39	4.38
DP1301B	SJ-46	DP1301B-012B-D	1	0.091		4.77	4.69
DP1301B	SJ-46	DP1301B-013-A	1	0.072	0.026	12.18	7.90
DP1301B	SJ-46	DP1301B-013-B	1			10.12	5.64
DP1301B	SJ-46	DP1301B-013-C	1			9.29	5.85
DP1301B	SJ-46	DP1301B-014	1			16.10	6.83
DP1301B	SJ-46	DP1301B-016	1			5.33	3.49
DP1301B	SJ-46	DP1301B-017	1			11.74	6.70
DP1301B	SJ-46	DP1301B-018	1			20.62	7.71
DP1301B	SJ-46	DP1301B-019	1			11.40	6.37
DP1301B	SJ-46	DP1301B-020	1			9.29	4.96
DP1301B	SJ-46	DP1301B-023-A	1			6.33	4.03
DP1301B	SJ-46	DP1301B-023-B	1	0.077		13.05	5.82
DP1301B	SJ-46	DP1301B-023-C	1			10.91	6.53
DP1301B	SJ-46	DP1301B-025-A	1			9.47	6.38
DP1301B	SJ-46	DP1301B-025-B	1	0.09	0.039	9.11	5.38
DP1301B	SJ-46	DP1301B-026-A	1			8.94	5.86
DP1301B	SJ-46	DP1301B-026-B	1			7.97	4.54
DP1301B	SJ-46	DP1301B-028-A	1	0.055		12.28	5.86
DP1301B	SJ-46	DP1301B-028-B	1			8.32	4.87
DP1301B	SJ-46	DP1301B-029-A	1			10.16	6.22
DP1301B	SJ-46	DP1301B-029-B	1			7.10	4.44
DP1301B	SJ-46	DP1301B-030	1			14.37	6.34
DP1301B	SJ-46	DP1301B-031	1			19.69	10.02
DP1301B	SJ-46	DP1301B-032	1			10.44	7.30
DP1301B	SJ-46	DP1301B-033	1			10.98	8.87
DP1301B	SJ-46	DP1301B-035	1			19.01	7.98
DP1301B	SJ-46	DP1301B-036	1			16.14	8.01
DP1301B	SJ-46	DP1301B-041	1			5.10	3.74
DP1301B	SJ-46	DP1301B-043-A	1	0.053		10.62	5.77
DP1301B	SJ-46	DP1301B-043-B	1			11.57	5.63
DP1301B	SJ-46	DP1301B-045	1			7.99	5.28
DP1301B	SJ-46	DP1301B-047-A	1	0.028		0.55	1.58
DP1301B	SJ-46	DP1301B-047-B	1			5.58	3.80
DP1301B	SJ-46	DP1301B-048-A	1	0.072		7.45	5.65

DP1301B	SJ-46	DP1301B-049	1			6.98										4.49
DP1301B	SJ-46	DP1301B-051-A	1			1.26										2.08
DP1301B	SJ-46	DP1301B-051-B	1			8.19										5.28
DP1301B	SJ-46	DP1301B-052-A	1	0.081		9.88										6.28
DP1301B	SJ-46	DP1301B-052-B	1			5.08										4.04
DP1301B	SJ-46	DP1301B-052-C	1			13.20										5.80
DP1301B	SJ-46	DP1301B-054	1	0.072		7.90										4.99
DP1301B	SJ-46	DP1301B-057	1	0.054		7.37										5.06
DP1301B	SJ-46	DP1301B-058	1			4.98										4.02
DP1301B	SJ-46	DP1301B-060	1			16.67										6.26
DP1301B	SJ-46	DP1301B-063-A	1	0.153	0.022	4.33										3.39
DP1301B	SJ-46	DP1301B-063-B	1			7.54										4.07
DP1301B	SJ-46	DP1301B-065	1			5.23										3.81
DP1301B	SJ-46	DP1301B-069-A	1			10.85										5.29
DP1301B	SJ-46	DP1301B-069-B	1			8.22										5.75
DP1301B	SJ-46	DP1301B-070-A	1			5.69										4.88
DP1301B	SJ-46	DP1301B-072-A	1			11.52										6.19
DP1301B	SJ-46	DP1301B-072-B	1	0.053		3.72										3.59
DP1301B	SJ-46	DP1301B-074	1			13.26										7.53
DP1301B	SJ-46	DP1301B-077	1			8.50										6.08
DP1301B	SJ-46	DP1301B-078	1			16.11										7.59
DP1301B	SJ-46	DP1301B-080	1			10.18										5.83
DP1301B	SJ-46	DP1301B-082	1			10.52										6.63
DP1301B	SJ-46	DP1301B-083-A	1			20.83										10.04
DP1301B	SJ-46	DP1301B-083-B	1	0.044	0.001	7.94										5.22
DP1301B	SJ-46	DP1301B-083-C	1			8.99										5.07
DP1301B	SJ-46	DP1301B-090-A	1	0.092		14.07										6.67
DP1301B	SJ-46	DP1301B-090-B	1			12.45										6.95
DP1301B	SJ-46	DP1301B-090-C	1			2.40										3.47
DP1301B	SJ-46	DP1301B-090-D	1			12.31										7.71
DP1301B	SJ-46	DP1301B-090-E	1	0.075		8.05										6.10
DP1301B	SJ-46	DP1301B-090-F	1			6.36										4.37
DP1301B	SJ-46	DP1301B-090-G	1			4.64										4.72
DP1301B	SJ-46	DP1301B-090-H	1			7.61										4.89
AF1402	SJ-50	AF1402-012-B	1			1.00										1.84
DP1301B	SJ-50	DP1301B-084	1			2.59										3.11
DP1301B	SJ-50	DP1301B-085	1			1.82										2.44
AF1407-C	SJ-53	AF1407-C-006	1	0.065		6.13										3.62
AF1402	SJ-55	AF1402-012-A	1			8.86										4.18
AF1407-C	SJ-63	AF1407-C-002	1			25.15										8.18
AF1404-C2	SJ-71	AF1404-C2-005	0			57.11	21	37.13	8.97	21.67	34.071	20.71	23			0.321
AF1404-C2	SJ-71	AF1404-C2-006	0				16.19	25.22		9.93	22.767	15.93	14	2		0.286
AF1404-C2	SJ-71	AF1404-C2-009A	0	0.073		15.29	10.696	18.682	6.652	6.04	16.819	10.762	12	3		0.223
AF1404-C2	SJ-71	AF1404-C2-001A	0	0.124		35.478	22.588	38.509	9.28	18.14	37.084	22.37	8			0.238
AF1404-C2	SJ-71	AF1404-C2-003A	0				9.461	15.71		9.99	15.085	9.35	5			0.124
AF1409D	SJ-71	AF1409-084	0	0.137	0.026	14.33	7.256	29.62	6.33	20.05	28.603	7.19	6			0.078
AF1409D	SJ-71	AF1409D-093	0				9.048	12.984		7.32	12.679	8.991	5			0.062
AF1409D	SJ-71	AF1409D-094	0	0.151		24.248	8.514	29.264	8.252	17.24	28.642	8.401	8			0.132
AF1409D	SJ-71	AF1409D-106	0	0.187	0.039	41.88	15.323	32.725	8.902	21.00	32.218	15.228	5			0.102
AF1404-C2	SJ-72	AF1404-C2-039	1			1.142				2.145						
AF1409D	SJ-76	AF1409D-098	0			25.682	7.855	26.813	8.208	18.93	26.109	7.774	17			0.095

AF1409D	SJ-76	AF1409D-099	0	0.278	0.146	14.644	4.777	18.313	6.59	11.18	17.96	4.741	6	2	0.042
AF1409D	SJ-76	AF1409D-102	0	0.217	0.082	15.176	6.972	17.683	5.849	9.03	17.079	6.872	9		0.11
AF1409D	SJ-77	AF1409D-059	0	0.072	0.014	26.398	10.208	29.412	7.095	18.63	29.133	10.186	6		0.028
AF1404-C2	SJ-78	AF1404-C2-015A	0				18.678	34.523		23.69	33.239	18.491	35		0.224
AF1407	SJ-78	AF1407-080	0				6.523	25.973		21.81	25.761	6.489	9		0.044
AF1407	SJ-78	AF1407-081	0				6.23	10.501		7.71	10.16	6.188	9		0.053
AF1407-C	SJ-78	AF1407-C-012	0			89.922	19.635	39.32	12.697	31.44	39.955	19.539	10		0.116
AF1409D	SJ-78	AF1409D-009	0				15.507	36.588		30.71	35.85	15.387	9		0.1
AF1409D	SJ-78	AF1409D-028	0			46.252	19.95	46.94	13.445	34.67	44.939	19.73	40		0.255
AF1409D	SJ-78	AF1409D-030	0	0.304		90.544	31.57	56.10	14.616	40.78	54.055	31.30	30		0.351
AF1409D	SJ-78	AF1409D-073	0	0.126	0.008	21.216			7.38						
AF1409D	SJ-78	AF1409D-099	0				17.15	27.53		21.55	26.631	17.00	19		0.178
AF1409C	SJ-80	AF1409C-010	1	0.075	0.028	25.196			6.529						
AF1409D	SJ-82	AF1409D-006	1			64.65			16.968						
AF1409C	SJ-88	AF1409C-025	0			42.624	13.543	49.055	7.664	38.17	48.324	14.674	9		0.036
AF1407	SJ-93	AF1407-086A/B	1	0.057		2.31			3.00						
AF1407	SJ-93	AF1407-087	1			4.243			4.00						
AF1404-C2	SJ-111	AF1404-C2-032A	0	0.103		48.741	16.872	45.804	10.504	26.152	45.207	16.837	18		0.046
AF1404-C2	SJ-112	AF1404-C2-033A	1	0.152	0.1	30.24			6.622						