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1 **The Senegal River during the last millennium**

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8

9 **Abstract**

10 The diatom and pollen assemblages of the upper 4.5 m of a core recovered from the bank of
11 the Senegal River upstream of St Louis (16.03 N, 16.48 W) reveal an exceptional diversity (39
12 diatom taxa from which 5 mentioned for the first time in Senegambia and 147 pollen taxa),
13 allowing reconstruction of the environmental history of the northern Sahel over the last
14 millennium. Our study confirms that the Little Ice Age was a period of increased dryness. This
15 resulted in the disappearance of tropical trees that were developed in gallery forests during
16 the Holocene humid period. However, freshwater inputs from the Senegal River remained
17 constant during the whole millennium while being strongly impacted by sea level variations:
18 An episode of sea level rise, already recorded in the Ferlo river valley, led to a supply of salt
19 waters up to 1250 CE. It was only after 1720 CE that a dramatic event occurred with the
20 massive development of marine to brackish diatoms at the expense of freshwater forms as a
21 result of the weakening of the Senegal river inputs. Increased dry conditions during the second
22 half of the 18th the 19th centuries culminating 1826 CE led to the salinization of the core site

23 with the development of *Avicennia* populations and halophilic plant species from the rear
24 mangrove.

25

26 **Key words:** Last millennium, Senegal river, Sea level, Diatoms, Pollen

27 **Introduction**

28 Since the great Sahelian drought of the 1970s, which had dramatic consequences on human
29 populations, the variability of the west African monsoon system has been the subject of
30 intense research (e.g., the AMMA project: [Redelsberger et al., 2006](#)). Instrumental data since
31 the beginning of the 20th century at St Louis (Northern Senegal) ([Gallego et al., 2015](#)) and
32 documentary sources from earlier centuries (in e.g., [Nicholson, 2001; 2012](#); [Coquery-
33 Vidrovitch, 1997](#); [Kane, 2002](#)), bear witness to this variability in reporting either exceptional
34 rainfall events at the origin of catastrophic floods in the valley of the Senegal River and its
35 tributaries or repeated dramatic dry years in the inner delta of the Niger River. This short-term
36 (annual to decadal) climatic variability was superimposed on a slow evolution towards an
37 increasing drought since about 3000 years ago ([Lézine et al., 2019](#)) which led to the
38 disappearance of most of the tropical plant species ([Hély et al., 2014](#)) and the drying up of the
39 water bodies ([Lézine et al., 2011](#)), which widely expanded throughout the Sahel and the
40 Sahara during the Holocene humid period.

41 The study of past climate variability in northern Senegal is largely hampered by the lack of
42 permanent freshwater bodies that would allow access to continuous high resolution
43 sedimentary series. The well-developed mangrove along the downstream sector of the
44 Senegal River may fill this gap mainly because of the high rate of sediment accumulation in

45 such an environment. (e.g., [Lézine et al., 2017](#)). However, mangroves are extremely sensitive
46 to local changes in their environment such as the formation of sandy banks or erosion by flood
47 events. The sediment accumulation is therefore rarely continuous and often presents
48 significant discontinuities (e.g. [Médus and Monteillet, 1981](#)). An additional difficulty comes
49 from the specific configuration of the Senegal River bed, whose level is located below the sea
50 level over about 250 km ([Cogels and Gac, 1983](#)). This Sahelian river was therefore regularly
51 subjected to marine water intrusion during the dry season before the Diama dam was built in
52 1985. As a consequence of this morphological configuration, sea level variations and/or
53 geoidal changes, even of very small amplitude, may have had major consequences on the river
54 environment leading to the development of mangroves along the Senegal river banks up to
55 500 km upstream ([Michel and Assémien, 1969](#)) or to the presence of marine shells as far south
56 as 15.6°N in the Ferlo river ([Faure et al., 1980](#); [Monteillet et al., 1981](#)).

57 Here we present the diatom and pollen records of the 4.5 upper meters of a 7 m-long core
58 recovered in the rear mangrove from the Senegal river bank in St Louis, Senegal, at 16.03 N
59 and 16.48 W. The goal of our study is to try to decipher the local (geomorphological) and
60 regional (climate) signals in the evolution of the river environment during the last millennium
61 and place them within the general context of long-term paleoenvironmental and paleoclimate
62 reconstructions from continental ([Lézine et al., 2019](#); [Lemonnier and Lézine, in prep](#)) and
63 marine ([Mulitza et al., 2010](#)) records in northern Senegal and off-shore.

64 **Environmental setting**

65 The Senegal river delta lies in the semi-arid to arid Sahelian band characterized by a coastal
66 climate with an average temperature of 24.5°C and total precipitation of 284 mm. The Senegal

67 River is a 1,760 km long seasonal river with a unimodal flow regime strongly influenced by the
68 Atlantic monsoon rains with peak flows recorded from August to November. Since the mid-
69 1980s, this flow regime has been regulated by two dams (Manantali in Mali, Diama located
70 27 km upstream of St-Louis) (Figure 1).

71 The local vegetation is composed of mangrove forests. Mangroves are littoral forests which
72 occur in the intertidal coastal plains. In Senegal, mangrove populations are poorly diverse,
73 with species distributed according to a gradient in decreasing water depth and increasing
74 salinity: *Rhizophora racemosa* requires freshwater from both rivers and summer rainfall
75 (Spalding et al., 1997) and dominates at the mouth of the rivers where it benefits from large
76 muddy areas and flooding from the sea-water. It reaches here its northernmost position
77 (Trochain, 1940; Adam, 1965). Upstream from the *Rhizophora* zone, *Avicennia germinans*
78 occurs on sand banks and salty soils in irregularly submerged areas in association with
79 *Paspalum vaginatum*. Its high tolerance to salinity allows it to grow in desertic areas, as far
80 north as the island of Tidra in Mauritania along the Atlantic coast of Africa (19.7°N) and further
81 north along the Red Sea or the Arabo-Persian Gulf. The rear mangrove, where salt is highly
82 concentrated, is characterized by the presence of various Amaranthaceae plant species and
83 rare trees (*Tamarix senegalensis*). At a regional scale, the vegetation surrounding the core
84 site is of steppic, semi-desertic type with rare trees mainly *Acacia* sp., *Balanites aegyptiaca*,
85 *Salvadora persica* and *Capparis decidua*. The herbaceous cover is discontinuous with short
86 grasses such as *Cenchrus biflorus*.

87 **Materials and methods**

88 A 7 m long core was collected in November 2014 from the *Rhizophora* mangrove in the
89 suburbs of St-Louis (16.03° N, 16.48° W) using a manual Russian corer (Jowsey, 1966). The
90 sediment consists of sandy clay with intercalations of sand levels. Shells and shell fragments
91 are found around 450 and 300 cm downcore. Plant debris are found in the uppermost levels
92 (Figure 1).

93 **Dating control and age model**

94 The radiocarbon dating reveals a strong discontinuity in the sedimentary deposition around
95 500 cm downcore. Such a pattern is often found in fluvial environments (Medus and
96 Monteillet, 1981). As a consequence, our study has only been focused on the 450 upper
97 centimeters corresponding to the last millennium with the base of the sequence dating back
98 to 916 CE. The time scale was obtained by fitting a 2nd-order polynomial curve to the profile
99 of calibrated ¹⁴C ages against depth (Stuiver et al., 2019) taking into consideration the
100 reservoir-age calculated off the Senegal River mouth of 511±176 BP (Ndeye, 2008) (Table 1;
101 Figure 2) and two additional control points at 50 cm and at the surface. Two shells fragments
102 were dated at 415.5 and 208.5 cm. As already mentioned in Lézine et al. (2019) the additional
103 control points were given by the first occurrence of *Casuarina equisetifolia* pollen grains in our
104 samples the parent trees of which were planted in 1948 in the area (Ndiaye et al., 1993) and
105 by the year of sampling (2014).

106 **Diatom and pollen analyses**

107 The core was sampled at 10 cm interval for both diatom and pollen analyses.

108 For diatom analyses samples were processed using a standard method (Battarbee, 1986). The
109 residue was diluted in 20 ml of water and 2 ml was taken, then dried and fixed with Naphrax.

110 Diatom identification was based on [Gasse \(1986\)](#), [Servant-Vildary \(1978\)](#), [Foged \(1986\)](#),
111 [Compère \(1991\)](#), [Denys \(1991\)](#), [Krammer and Lange-Bertalot \(1986, 1988, 1991a, 1991b\)](#),
112 [Germain and Bourrelly \(1981\)](#), [Simonsen \(1987\)](#), [Carter and Denny \(1981\)](#). In addition, [Zanon](#)
113 [\(1941\)](#), [Guermeur \(1954\)](#), [Amosse \(1970\)](#), [Leuduger-Fortmorel \(1898\)](#), [Ouattara et al \(2000\)](#),
114 [Sow \(2006\)](#), [Sow and Diène \(2002\)](#), [Sow et al. \(2005; 2006a and b; 2012; 2013\)](#), [Fofana et al.](#)
115 [\(2014\)](#), [Badiane et al \(2016\)](#), [Nguetsop et al. \(2011; 2013\)](#), [Lézine et al. \(2019\)](#) were used to
116 precise the ecological requirement of taxa. Thirty-nine diatoms were determined among
117 which 5 for the first time in Senegambia ([Table 2](#)). They correspond to four main hydrological
118 conditions: freshwater, freshwater/salt tolerant, brackish and marine waters. Diatoms are
119 presented as percentages calculated against the sum of all the diatoms counted ([Figure 3](#)).

120 For pollen analyses samples were processed using the standard HF method described by
121 [Faegri and Iversen \(1977\)](#). After sieving in a 5 µm mesh, the residue was stained with safranin
122 and mounted in glycerine. Pollen identification was based on the reference slide and photo
123 collections of the LOCEAN laboratory and the Museum national d'Histoire naturelle in Paris as
124 well as on pollen atlases of tropical African flora from e.g., [Maley \(1970\)](#), [APLF \(1974\)](#), [Ybert](#)
125 [\(1979\)](#) and [Bonnefille and Riollet \(1980\)](#). Pollen nomenclature, which follows the standard
126 defined by the African Pollen Database ([Vincens et al., 2007](#)), was based on [Lebrun and Stork](#)
127 [\(1991-2015\)](#). The pollen microflora was composed of 147 taxa. Pollen taxa were grouped
128 according to the phytogeographical and ecological affinity of the parent species following
129 [Lézine et al. \(2009\)](#) with dry tropical (including Saharan, Sahelian and Sahelo-Sudanian pollen
130 types), humid tropical (including Sudano-Sahelian, Sudanian, Sudano-Guinean and Guinean
131 pollen types), mangrove, wet indicators, cultivated plants and undifferentiated (including
132 Poaceae) ([Table 3](#)). Pollen percentages were calculated against a sum excluding mangrove

133 pollen types, wet pollen types and ferns, the percentages of which were calculated separately
134 against a sum including all the pollen grains and fern spores counted (Figure 4).

135 Both pollen and diatom data are presented under the form of percentage diagrams using Tilia
136 software (Grimm, 1991).

137 **Results**

138 **Diatoms**

139 The diatom content is extremely low between the base and 100 cm down core (dated 1576
140 CE) where less than 50 specimens in total per sample could be counted. This number reaches
141 up to 351 in the upper meter. This explains the variability of the percentages, particularly at
142 the base of the diagram. However, on the basis of variations in major taxa, three main zones
143 have been distinguished.

144 **Zone 1, from the base to 1240 CE**, is characterized by the dominance of *Thalassiosira* sp
145 associated with *Triceratium favus*, *Thalassiosira decipiens*, *Terpsinoe americana*, all marine to
146 brackish water indicators. However, the presence of *Navicula viridula*, *Stauroneis anceps*,
147 *Caloneis bacillum*, and *Eunotia flexuosa* associated with *Nitzschia acicularioides*,
148 *Achnantheidium catenatum*, and *Cyclotella meneghiniana* in minor proportion suggests that
149 the fresh water influence was also present.

150 **Zone 2, from 1240 to 1720 CE**, is typified by the disappearance of the marine taxon
151 *Thalassiosira* sp which dominated in the preceding zone. Two sub-zones can be distinguished:
152 In zone 2a, from 1240 to 1600 CE, *Cyclotella striata*, *C. meneghiniana*, *Nitzschia separanda*, *N.*
153 *radiopunctata* and *Achnantheidium catenatum* occur, suggesting that the freshwater influence

154 increased. In zone 2b (from 1600 to 1720 CE) this freshwater influence is confirmed by the
155 peak of *Navicula radiopunctata* percentages (60%).

156 **Zone 3, from 1720 CE onward** is characterized by disappearance of the taxa present in zone
157 2, and their replacement by *Nitzschia separanda* which reaches here its highest values (80%).
158 This taxon is associated with *Eunotia pectinalis* which regularly increases from the base of sub-
159 zone 2b to the level dated 1919 CE (25%) as well as, in a lesser extent, *T. decipiens*. The
160 increase in *Aulacoseira granulata*, *Thalassiosira decipiens* and *Diploneis subovalis* in the upper
161 levels, allows individualization of sub-zone 3b (post-1965 CE). All this indicate a drastic change
162 in the environment dominated by saline conditions. The great number of diatom frustules
163 gives a high validity to this zone, compared to the lower ones where diatoms were poorly
164 preserved.

165 **Pollen**

166 Despite its high floral richness ([Table 3](#)), low amplitude variations characterize the pollen
167 record ([Figure 4](#)). Most of the taxa appearing only once. Two main zones can however be
168 distinguished:

169 **Zone 1, from 900 to 1600 CE:** This zone is characterized by the presence of tropical trees from
170 gallery forests and savannahs, among which *Uapaca*, *Anogeissus*, *Celtis*, *Mitragyna intermis*,
171 *Alchornea*, different types of *Combretum* and *Acacia*. Although in low percentages, they are
172 nevertheless constant. They are associated with indicator taxa of sub-desert environments
173 such as *Suaeda*, *Aerva/Cornulaca*, Asteraceae. Poaceae largely dominate the spectra
174 underlining the open nature of the environment. Within the mangrove, *Rhizophora* dominates
175 but its percentages remain below 20% (sous-zone 1a). Ferns spores are regularly present.

176 At 1370 CE, sub-zone 1b differs from the previous one in that the increase in mangrove taxa
177 (*Avicennia* and *Rhizophora*) reaches up to 39% in total. This increase is parallel to that of the
178 herbaceous taxon *Gnaphalium*-type *luteo-album*, characteristic of the former coastal dunes
179 (Trochain, 1940) of northern Senegal in a very open steppe environment or of the salty soils
180 of the Saloum delta (Adam, 1958).

181 **Zone 2 from 1600 CE onward:** With the exception of *Celtis* and *Alchornea*, which are still
182 remarkably present in sub-zone 2a (1600-1720 CE), the taxa mentioned above are decreasing
183 or disappearing in favor of typical Sahelian taxa, in particular *Balanites*. Sub-zone 2a
184 characterized by the maximum of mangrove and saline environment taxa. Steppe taxa
185 (Aizoaceae, *Cassia*-type) are well represented. Sub-zone 2b (1720-2014 CE) is characterized
186 by the decrease of the mangrove indicators and the increase of *Tamarix* indicating the drying
187 of the regional environment.

188 Discussion

189 Our record gives evidence of a complex environmental history where two distinct signals are
190 superimposed: the regional environment of northern Senegal and the littoral and river
191 environment including the mangrove forest.

192 The regional environment

193 The regional environment of SL 14-01 was open and dry as shown by the dominance of
194 Poaceae and the continuous occurrence of herbaceous plant types indicative of salt and
195 steppic conditions (e.g., *Suaeda*, *Aerva/Cornulaca*). Trees were rare except *Uapaca* and *Celtis*
196 and in a lesser extent *Syzygium* which testify for the presence of a gallery forest of humid
197 tropical affinity in the immediate surroundings of the core site. These taxa are currently

198 common in the Sudanian and Sudano-Guinean dry forests south of 14°N. They widely
199 extended along the shores of Guiers lake and in the Niaye interdunal depressions during the
200 Holocene (Lézine, 1988). As a whole tropical trees did not exceed 10% in total showing that
201 the gallery forests were only poorly developed, having already retreated from northern
202 Senegal compared to their Holocene distribution (Watrín et al., 2009; Hély et al., 2014). Their
203 decrease was accentuated from 1365 EC to a minimum at 1826 EC. This evolution is coeval to
204 that observed in the Niaye interdunal depression along the northern coast of Senegal (Lézine
205 et al., 2019) where a minimum of tropical trees was reached at 1845 CE (Figure 5A). The wet
206 indicators trend recorded in SL 14-1 shows that the retreat of tropical gallery forests types
207 occurred within a period of increased drought conditions from the onset of the last
208 millennium, which continued during the Little Ice Age (Lézine et al., 2019). This record clearly
209 fits with the increase in dust fluxes to the ocean as reflected by the terrigenous sedimentary
210 fraction recorded off shore in core GeoB 9501 (Mulitza et al., 2010). The slight increase of the
211 wet indicators in the uppermost levels of SL 14-1, which is coeval with a return of a woodier
212 environment in the Niaye area could correspond to a short period of increased monsoon rains
213 in 1869-1890 (Gallego et al., 2015). Nevertheless, humidity was not sufficient to induce a
214 recovering of the tropical humid plant types in the Senegal river valley. Contrasting with this
215 slow evolution of the regional environment, the hydrology of the Senegal river dramatically
216 changed within only one century. This abrupt change is characterized by the replacement of
217 freshwater diatom communities by almost exclusively marine ones showing that the
218 freshwater flow of the Senegal River has decreased considerably at the end of the 17th
219 century CE, allowing marine waters to expend upstream.

220 **Saline invasion in the river bed and mangrove development**

221 Abundant macro-remains and pollen grains of *Rhizophora* have been recovered in the Senegal
222 river delta, and upstream (e.g., Médus and Monteillet, 1981; Michel and Assémien 1969-1970)
223 including the adjacent Guiers lake (Lézine, 1988), testifying for the wide extent of this littoral
224 forest during the last massive marine transgression, the “Nouakchottian” around 5.5 kyrs BP.
225 Marine shells show that the influence of seawater persisted beyond this period outside the
226 current mangrove forest zone in the river delta even during the last millennium ((Michel et al.,
227 1968; Faure et al., 1980; Evin et al., 1983) (Supplementary Table). Mangrove mollusk shells of
228 *Tympanotonus fuscatus* and *Tagelus angulatus* have been found outside their current
229 distribution as far as the Ferlo river bed, upstream of Guiers Lake (Monteillet et al., 1981)
230 (Figure 5D). These species mainly occur today in sandy-silty areas characterized by low to
231 moderate energy in mangroves and rear-mangroves (Elouard and Rosso, 1977). Their
232 presence show that a marine transgression occurred under dry climate conditions between
233 927 to 1039 CE. Our data strongly support this overall evolution of the littoral environment
234 over the last millennium:

235 - Despite their anemophilous way of dispersion, *Rhizophora* pollen grains are known to
236 be poorly transported outside their source zone. A Study of modern pollen deposition
237 along the Senegal river (Lézine, 1988) shows that they reach 46% within the
238 *Rhizophora* forest and decline rapidly with distance to values below 5%. The values
239 encountered during the first half of the last millennium up to 1576 BC are around 20%,
240 which indicates that *Rhizophora* was present at the study site, although at a moderate
241 density. Its wide distribution at that time is consistent with the presence of
242 mangrove/marine shells found inland, in arid areas south and north-east of St-Louis
243 (near Guembeul and in Lampsar/Djeuss area) (Figure 5D). The availability of

244 freshwater, crucial for *Rhizophora* mangrove development, is attested by the presence
245 of freshwater diatoms such as *Achnanthisidium catenatum* and *Navicula radiopunctata*,
246 and freshwater to salt-tolerant diatoms such as *Nitzschia acicularioides*, *Cyclotella*
247 *meneghiniana* and *Discostella stelligera* (Figure 5C), indicating that the Senegal river's
248 contribution was constant. The increase of *Avicennia* percentages at 1576 CE reveals a
249 dramatic environmental change with the setting of more saline conditions at the core
250 site (Figure 5E). Dry and salty conditions are confirmed by the presence of *Gnaphalium*
251 *luteo-album* among the pollen types. Similarly, brackish to marine taxa dominate the
252 diatom assemblages (*Nitzschia separanda*, *Thalassiosira decipiens*, *Thalassiosira sp.*,
253 *Eunotia pectinalis*). However, *Rhizophora* remained present and it is only after 1782 CE
254 that their populations strongly declined.

255 - The diatom record closely matches the shell record of the Ferlo river in showing the
256 presence of marine and brackish taxa up to 1250 CE. We interpret this finding as
257 reflecting the marine invasion related to the sea level rise event revealed by the
258 mollusk shells. As a consequence, the interval of freshwater dominant diatom
259 assemblage from 1275 to 1655 CE does not reflect a phase of increased humidity but
260 only the retreat of the salt waters linked to the sea level lowering.

261 **Conclusion**

262 Core SL14-01 shows that the Senegal River delta has had a complex history over the past
263 millennium. Two distinct influences were at play: (1) sea level variations induced strong
264 ecological changes in the diatom flora. The sea level rise episode ca 900-1000 CE, already
265 mentioned by [Monteillet et al \(1981\)](#) based on the study of marine shells from the Ferlo river
266 valley, is confirmed. It is reflected by the presence of marine diatoms that mixed with

267 freshwater ones from the Senegal River at the onset of the last millennium; (2) increasing dry
268 environmental conditions during the Little Ice Age, as already recorded further south, in the
269 Niaye area (Lézine et al., 2019) led to the gradual disappearance of tropical trees which widely
270 expanded along the shores of Guiers lake (Lézine, 1998) and more widely in the Sahel and the
271 Sahara (Hély et al., 2014) during the Holocene Humid Period. Contrasting with the gradual
272 trend toward drier vegetation revealed by the pollen record, diatom assemblages show that
273 the hydrological system has undergone an abrupt change, during which freshwater inputs
274 from the Senegal River have declined significantly, leaving the possibility for marine waters to
275 rise at least to the core site.

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440

441 **Table and Figure captions**

442 **Figure 1** : Map of the lower valley of the Senegal river including the Ferlo river and Guiers Lake.

443 The left panel shows the location of core SL 14-01 (red dot) and sites cited in the text. Bleu
444 dots show the marine shells testifying for the past extension of marine influence during the
445 last millennium ([Supplementary Table](#)). The right panel shows the core SL 14-01 sediment
446 accumulation and ¹⁴C measurements on shells and shell fragments.

447 **Figure 2**: Core SL 14-01 age model

448 **Figure 3**: Synthetic diagram of core SL 14-01 showing percentages of selected diatom taxa. In
449 grey: 10x magnification

450 **Figure 4**: Synthetic pollen diagram for core SL 14-01 showing selected pollen taxa. In grey: 10x
451 magnification

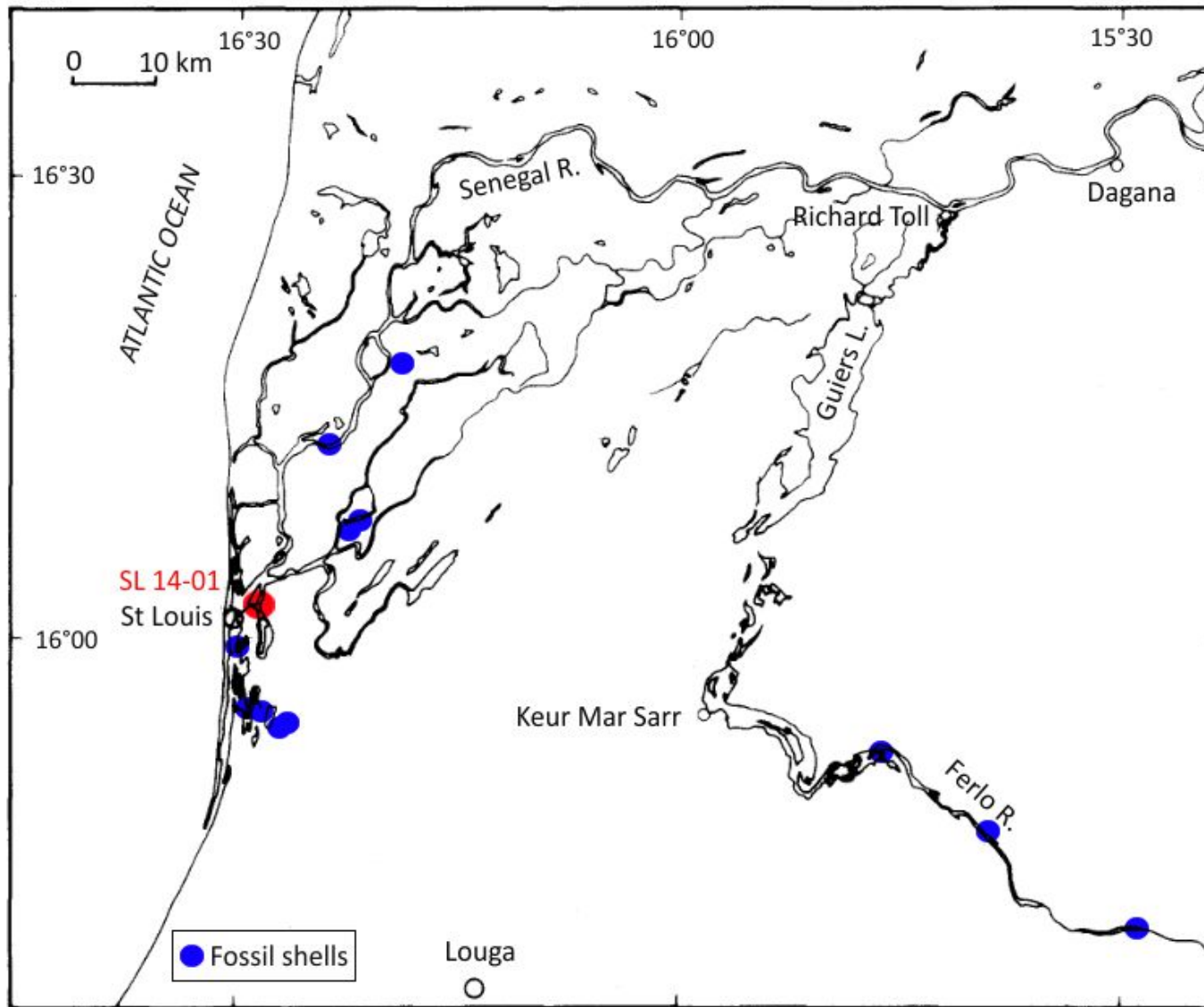
452 **Figure 5**: Evolution of the environment of the Senegal River over the last millennium showing
453 in the bottom panel the regional environment with A: SL 14-01 pollen percentages of two
454 groups: tropical trees and local wet indicators and tropical trees Mboro Baobab ([Lézine et al.,](#)
455 [2019](#)); B: the marine core GeoB 9501 terrigenous record indicative of dust transport ([Mulitza](#)
456 [et al, 2010](#)); in the top panel the river environment with C: Synthetic diatom diagram for SL
457 14-01 indicating fluctuations in the three main ecological groups brackish/marine,
458 intermediate (freshwater salt tolerant) and freshwater); D: Age of marine shells recovered in
459 the Senegal river delta ([Michel et al., 1968](#); [Faure et al., 1980](#); [Evin et al., 1983](#)) and Ferlo river
460 ([Monteillet et al., 1981](#)). In brackets, an age considered as a possible contamination by the
461 authors; E: SL 14-01 *Rhizophora*/*Avicennia* ratio illustrating the evolution of mangroves at the
462 core site.

463 **Table 1:** ^{14}C measurements and additional control points used to construct the age model of
464 core SL 14-01. Dating on marine shells were conducted at UMS-ARTEMIS AMS Facilities
465 (France).

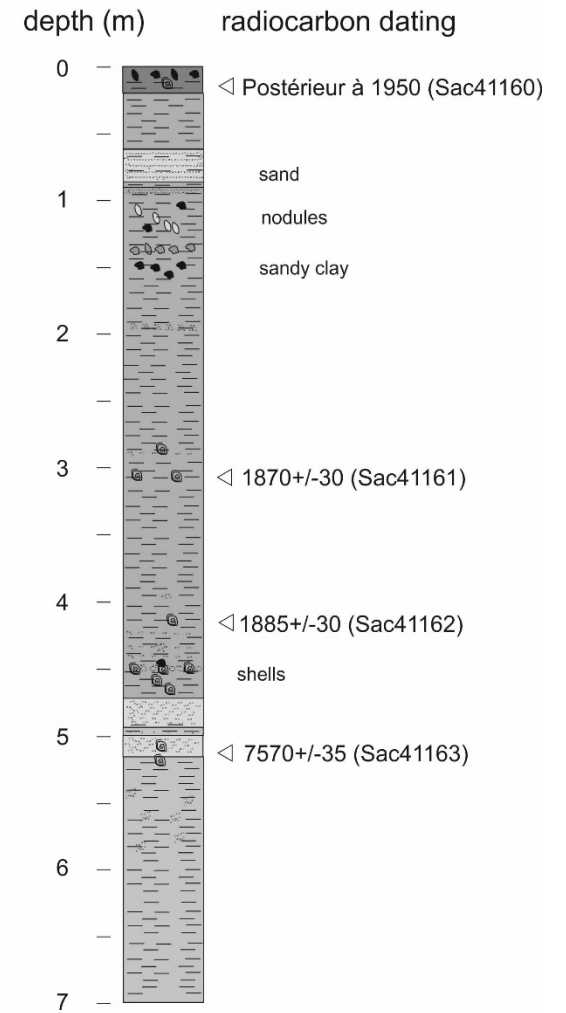
466 **Table 2:** list of diatom taxa encountered in SL 14-01 with their ecological requirements.

467 **Table 3:** list of pollen taxa recovered in SL 14-01 grouped according main
468 phytogeographical/ecological groups in western Africa. (Nomenclature from [Vincens et al.,](#)
469 [2007](#))

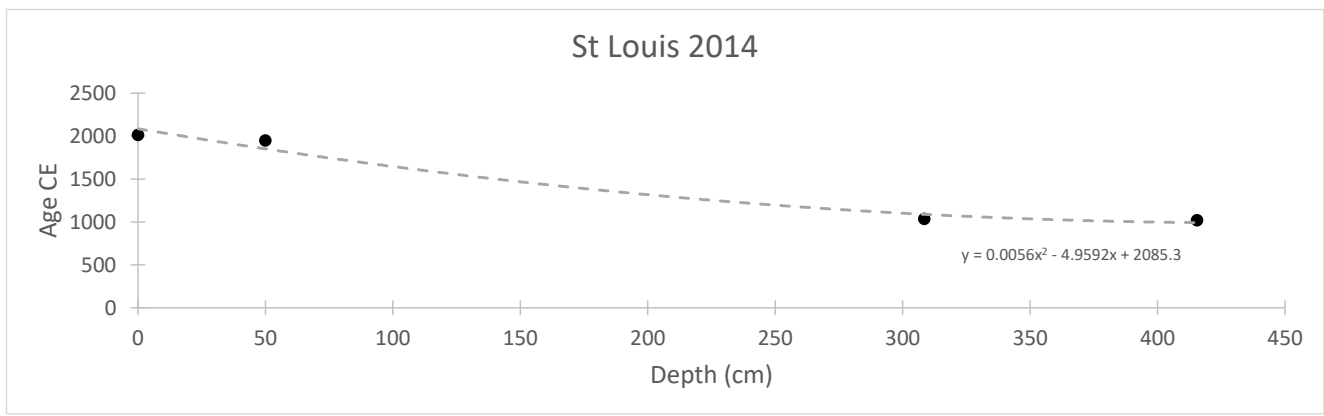
470 **Supplementary Table:** Littoral and mangrove shells recovered in the Senegal river delta and
471 the Ferlo river. Ages were calibrated using Stuiver et al (2019) taking into account the
472 reservoir age calculated by Ndeye (2008) off the Senegal coast.



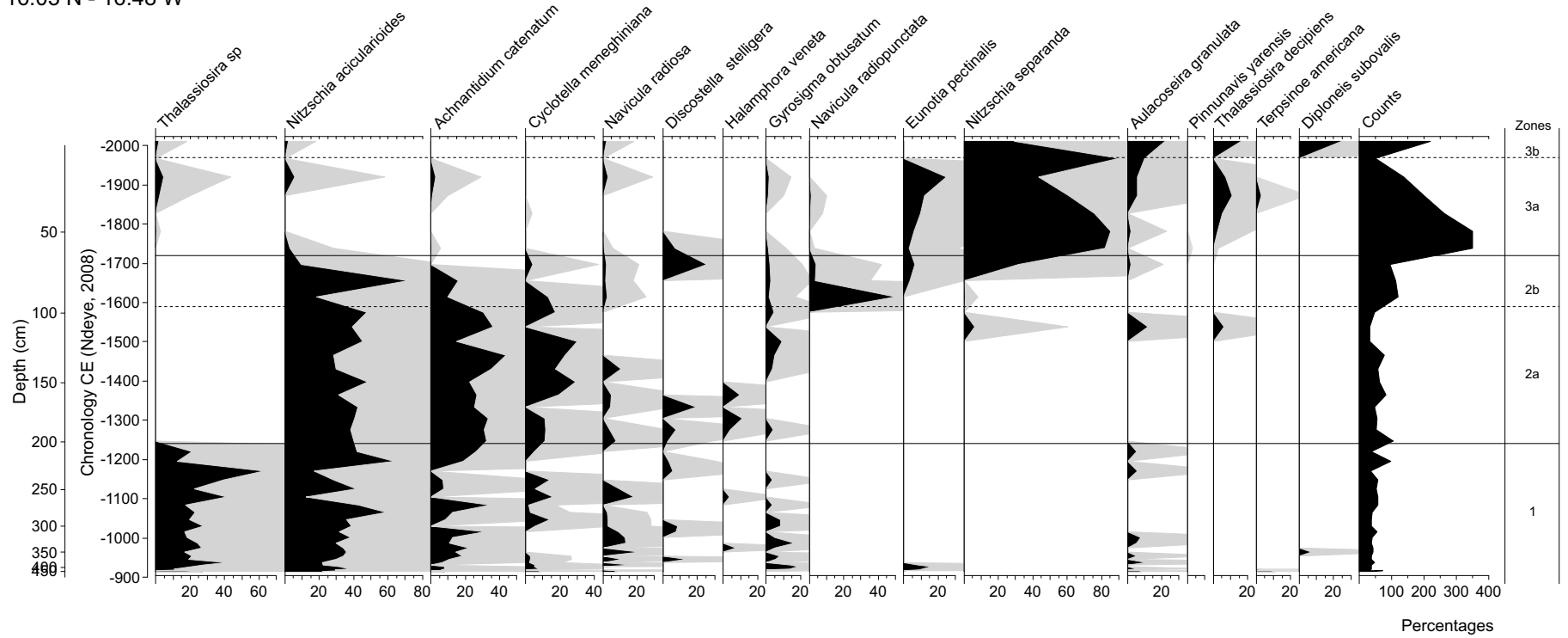
Mangrove St Louis SL14-01 16,03508/16,48382



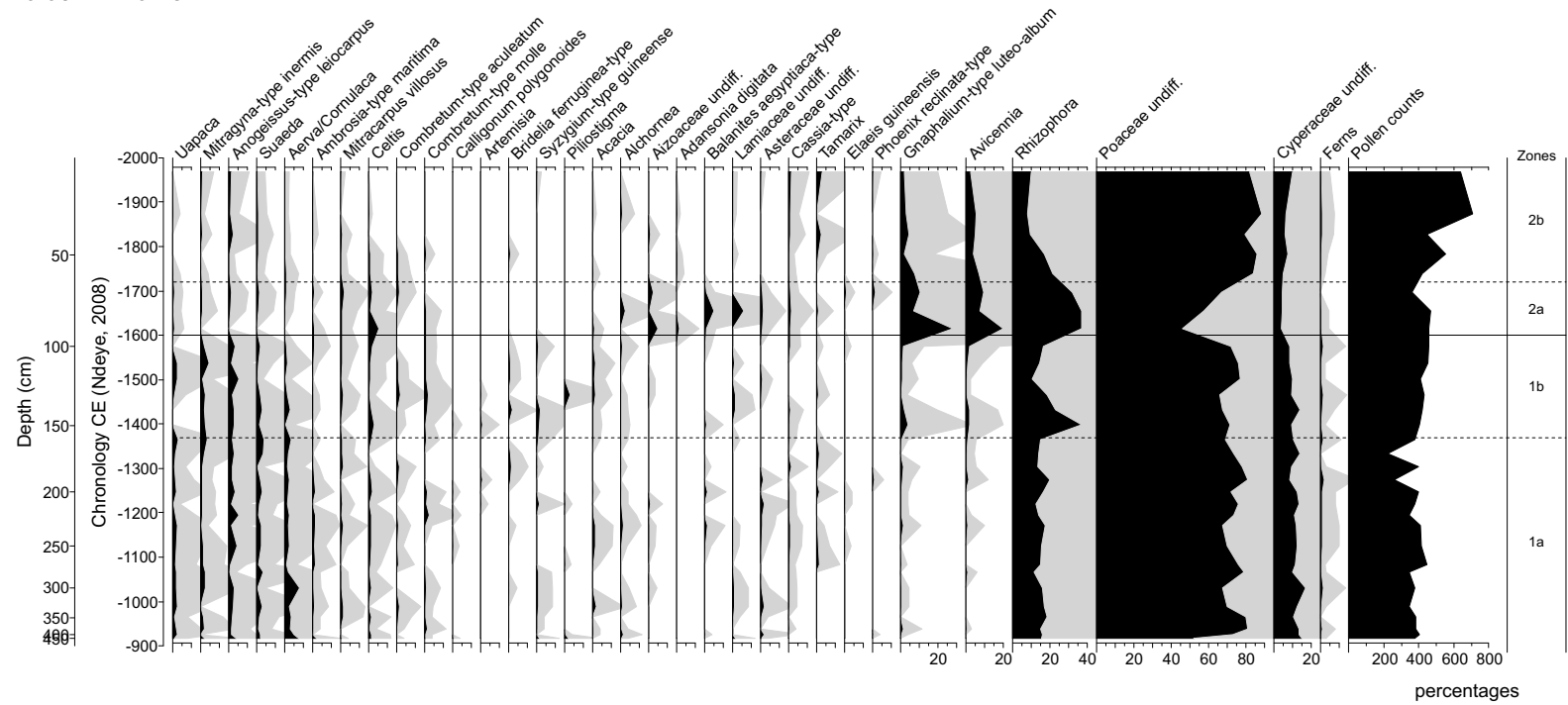
St Louis 2014

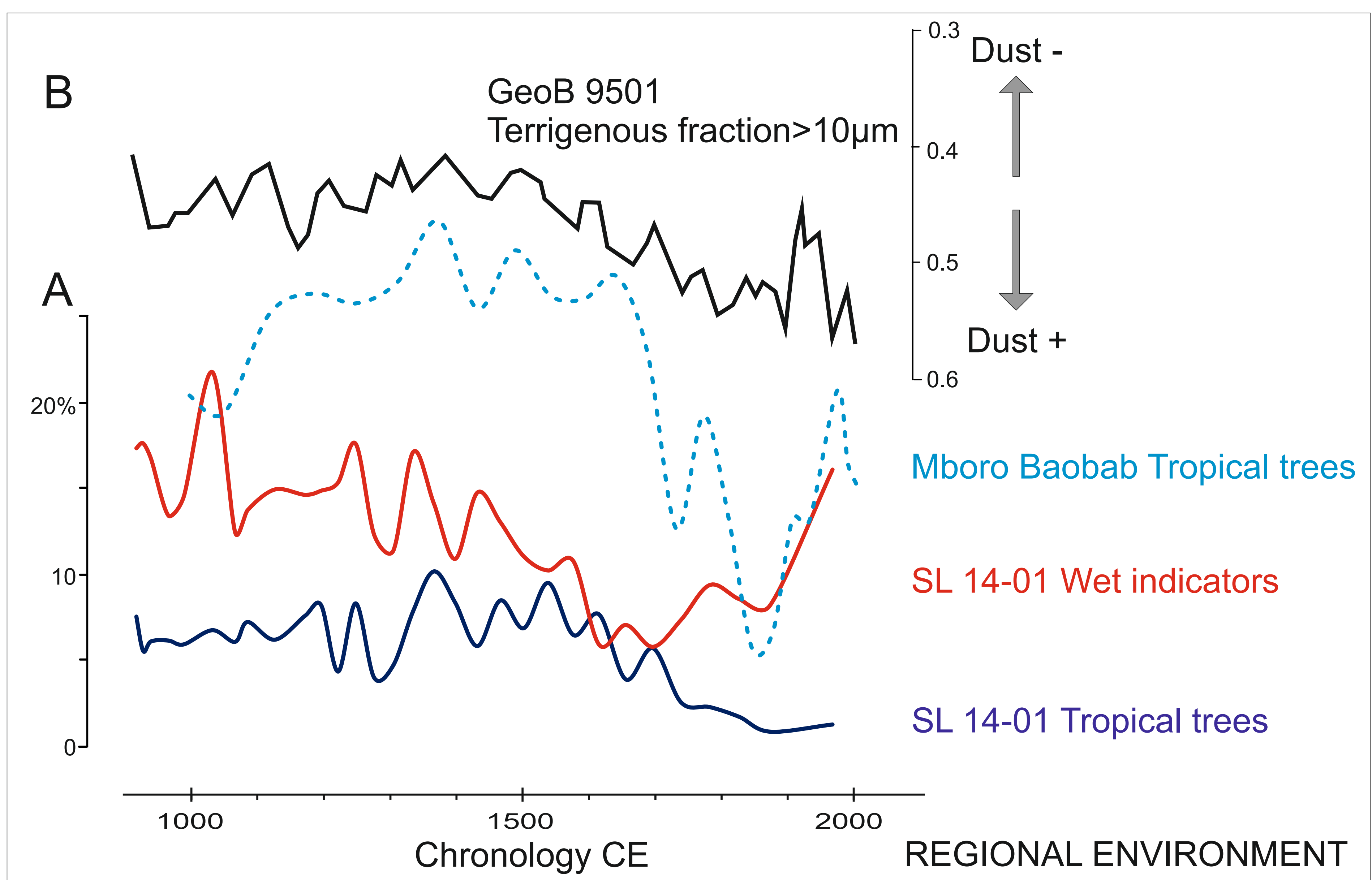
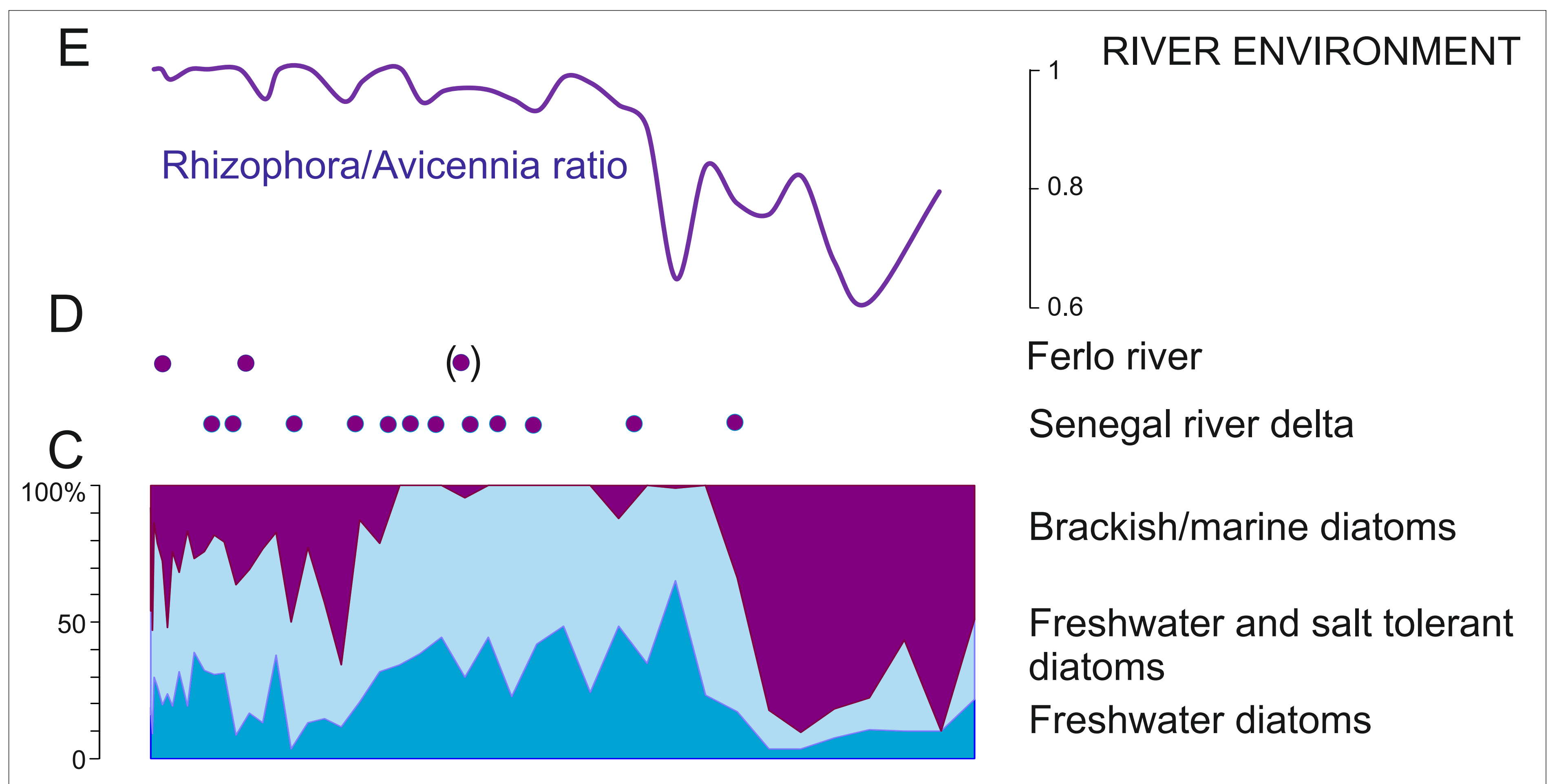


Saint Louis 2014 - main diatom taxa
 16.03 N - 16.48 W



St Louis 2014 - main pollen taxa
 16.03 N - 16.48 W





14C measurements		ΔR Ndeye 511 ± 176 BP
Lab. Nbr.	depth (cm)	Age cal CE
SacA41161	308-309	872 - 1230
SacA41162	415-416	853 - 1214

Additional control points		
	0.5	2014
	50	1948

DIATOM TAXA	freshwater	Freshwater/salt tolerant	brackish waters	marine waters
<i>Achnantidium catenatum</i>	+			
<i>Actynoptychus splendens</i>			+	+
<i>Aulacoseira granulata</i>	+			
<i>Caloneis bacillum</i>	+	+		
<i>Campylodiscus clypeus</i>	+			
<i>Cyclotella meneghiniana</i>	+	+	+	
<i>Cyclotella striata</i>			+	
<i>Diatomella balfouriana</i> *	+			
<i>Diploneis bombus</i>			+	+
<i>Diploneis didyma</i>	+	+		
<i>Diploneis subovalis</i>	+	+		
<i>Discostella stelligera</i>	+	+		
<i>Encyonema vulgare</i>	+			
<i>Eunotaia garusica</i>	+			
<i>Eunotia pectinalis</i>	+	+		
<i>Gyrosigma obtusatum</i>	+			
<i>Halamphora veneta</i>	+			
<i>Hantzschia amphioxys</i>	+	+	+	
<i>Navica cohnii</i>	+			
<i>Navicula radiopunctata</i>	+			
<i>Navicula radiosa</i>	+	+		
<i>Navicula viridula</i>	+			
<i>Nitzschia acicularioides</i> *	+	+		
<i>Nitzschia scalaris</i>	+	+	+	
<i>Nitzschia separanda</i> *			+	+
<i>Pinnularia macilentia</i>	+			
<i>Pinnularia neomajor</i>	+			
<i>Pinnunavis yarensis</i>		+	+	
<i>Placoneis sp</i> *	+			
<i>Rhopalodia gibba</i>	+	+	+	
<i>Rhopalodia gibberula</i>	+	+		
<i>Stauroneis anceps</i>	+			
<i>Surirella biseriata</i>	+			
<i>Surirella braunii</i>	+			
<i>Surirella elegantula</i>	+			
<i>Terpsinoe americana</i>				+
<i>Thalassiosira decipiens</i>			+	+
<i>Thalassiosira sp</i> *			+	+
<i>Triceratium favus</i>			+	+

(*) Diatom species first mentioned in Senegambia

DRY TROPICAL	HUMID TROPICAL	<i>Heliotropium lithospermoides/Echiochilon verrucosum</i>	Sapotaceae undiff.
<i>Acacia</i>	<i>Allophylus</i>	<i>Hypoestes</i> -type	<i>Syzygium</i> -type <i>guineense</i>
<i>Achyranthes</i> -type	<i>Acalypha</i>	<i>Ipomoea</i> -type	<i>Tapinanthus</i> -type
<i>Adenium obesum</i> -type	<i>Adansonia digitata</i>	<i>Keetia</i> -type <i>cornelia</i>	<i>Tetracera alnifolia</i> -type
<i>Aerva/Cornulaca</i>	<i>Afzelia africana</i> -type	<i>Kohautia</i>	<i>Tiliacora</i> -type <i>funifera</i>
<i>Aerva</i> -type <i>javanica</i>	<i>Albizia</i> -type	<i>Lamiaceae</i> undiff.	<i>Treculia africana</i> -type
Aizoaceae undiff.	<i>Alchornea</i>	<i>Lepidagathis</i>	<i>Trilepisium</i> -type <i>madagascariensis</i>
Amaranthaceae undiff.	Anacardiaceae undiff.	<i>Lepistemon owariense</i> -type	<i>Uapaca</i>
<i>Amaranthus/Chenopodium</i>	<i>Anogeissus</i> -type <i>leiocarpus</i>	<i>Lotus</i>	<i>Zanthoxylum</i> -type
<i>Ambrosia</i> -type <i>maritima</i>	<i>Anthostema</i> -type <i>senegalense</i>	<i>Maerua</i> -type	<i>Zanthoxylum</i> -type <i>zanthoxyloides</i>
Apiaceae undiff.	<i>Bridelia ferruginea</i> -type	<i>Margaritaria discoidea</i>	
<i>Artemisia</i>	<i>Cardiospermum halicacabum</i> -type	<i>Matricaria</i> -type	WET ENVIRONMENTS
<i>Arthrocnemum macrostachyum</i> -type	<i>Ceiba pentandra</i>	<i>Mitracarpus villosus</i>	<i>Aeschynomene</i>
<i>Asteraceae</i> undiff.	<i>Celtis</i>	<i>Phyla</i> -type	<i>Azolla</i>
<i>Atractylis</i> -type	<i>Chrysobalanus icaco/Parinari</i>	<i>Phyllanthus</i> -type <i>maderaspatensis</i>	<i>Caperonia</i>
<i>Atriplex</i> -type	<i>Clausena anisata</i>	<i>Phyllanthus</i> -type <i>reticulatus</i>	<i>Ceratopteris cornuta</i>
<i>Balanites aegyptiaca</i> -type	Combretaceae undiff.	<i>Piliostigma</i>	<i>Cyperaceae</i> undiff.
Brassicaceae undiff.	<i>Combretum</i> -type <i>aculeatum</i>	<i>Polycarpaea</i> -type	<i>Lycopodium</i>
<i>Calligonum polygonoides</i>	<i>Combretum</i> -type <i>molle</i>	<i>Polygala</i> -type	<i>Lygodium microphyllum</i>
Caryophyllaceae undiff.	<i>Commelina</i> -type <i>benghalensis</i>	Resedaceae undiff.	<i>Mimosa pigra</i> -type
<i>Cassia</i> -type	<i>Daniellia</i>	<i>Rumex</i>	Monoletes sp.
<i>Celosia</i> -type	<i>Detarium senegalense</i> -type	<i>Salix</i>	Monoletes undiff.
<i>Centaurea</i> -type <i>perrottetii</i>	<i>Dialium</i>	<i>Salvadora persica</i> -type	<i>Nymphaea lotus</i> -type
<i>Cerastium</i> -type	<i>Elaeis guineensis</i>	<i>Spermacoce</i> -type	<i>Phoenix reclinata</i> -type
Cichorieae undiff.	<i>Ficus</i>	<i>Spermacoce</i> -type <i>radiata</i>	<i>Polycarpon</i> -type
<i>Cissus</i>	<i>Flabellaria</i> -type <i>paniculata</i>	<i>Suaeda</i>	<i>Polygonum senegalense</i> -type
<i>Cleome</i> -type	<i>Hymenocardia acida</i> -type	<i>Tamarindus</i> -type <i>indica</i>	<i>Pteris</i> -type
<i>Cleome</i> -type <i>gynandra</i>	<i>Isoberlinia</i> -type	<i>Tamarix</i>	<i>Ruppia maritima</i>
<i>Cocculus</i>	<i>Ixora</i> -type <i>brachypoda</i>	<i>Tribulus</i>	Triletes undiff.
<i>Commiphora</i>	<i>Lannea</i> -type	<i>Vangueria</i> -type	<i>Typha</i>
<i>Convolvulus</i> -type	<i>Lophira alata</i> -type	<i>Ziziphus</i> -type	
<i>Dichrostachys cinerea</i> -type	<i>Macaranga</i> -type	UNDIFFERENTIATED	MANGROVE

<i>Ephedra fragilis</i> -type	<i>Mallotus</i> -type	Rubiaceae undiff.	<i>Avicennia</i>
<i>Eriosema</i> -type	<i>Meliaceae undiff.</i>	Acanthaceae undiff.	<i>Rhizophora</i>
<i>Erodium</i>	<i>Mitragyna</i> -type <i>inermis</i>	Fabaceae undiff.	CULTIVATED
<i>Euphorbia</i> -type	<i>Morelia senegalensis</i>	Mimosaceae undiff.	<i>Anacardium occidentale</i>
<i>Faidherbia albida</i>	<i>Nauclea</i> -type	Monocotyledoneae undiff.	<i>Casuarina equisetifolia</i>
<i>Gnaphalium</i> -type <i>luteo-album</i>	<i>Pavetta</i>	Poaceae undiff.	<i>Citrus</i>
<i>Gomphrena</i>	<i>Prosopis</i> -type <i>africana</i>	Undetermined	<i>Parkinsonia</i>
<i>Grewia</i> -type	<i>Psydrax</i> -type <i>subcordata</i>	Urticaceae undiff.	