Regional drought stress and local compensation

geomorphology and hydrology determining forest survival during the Last Glacial Maximum and Late Holocene

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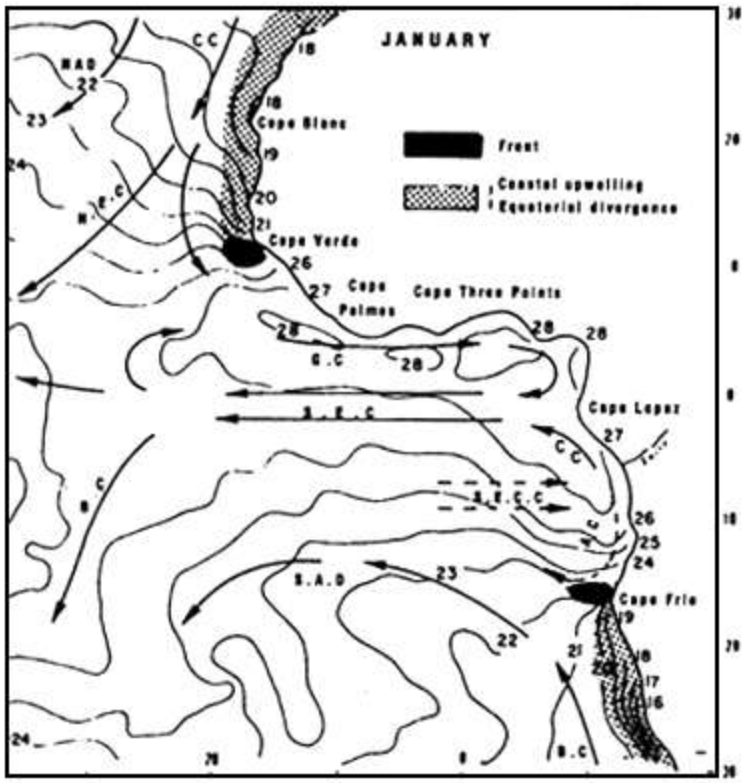
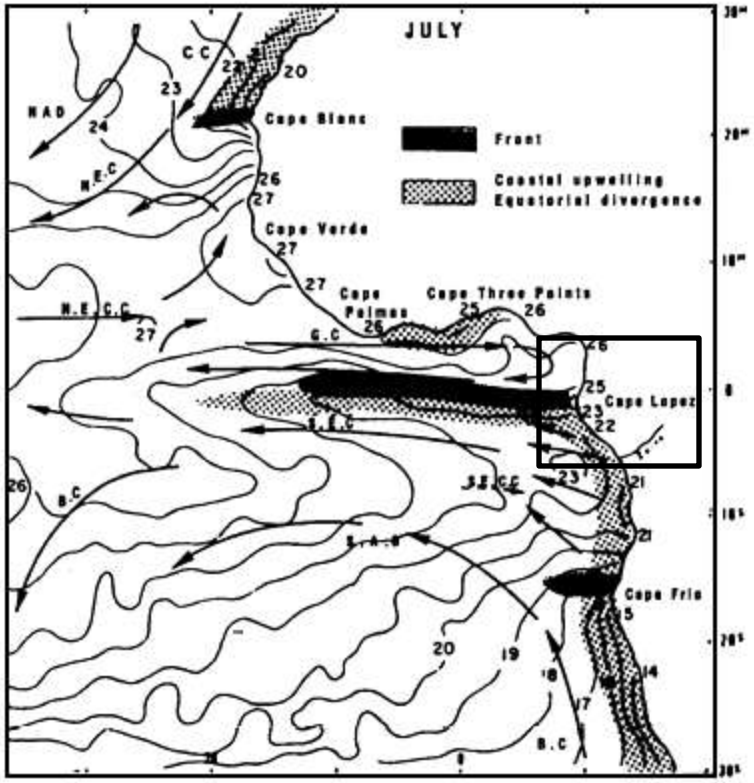
Climate change & dieback of forest

- Last Glacial Maximum (LGM) 18,000 yrs ago
  - Lake fossil pollen records (e.g. Maley 1996;2001)
  - Deep sea fossil pollen records (e.g. Lezine & Vergnaud-Grazzinni, 1993)
- Late Holocene Perturbation (LHP) 2,500 yrs ago
  - Fossil pollen records (Elenga et al., 1991; Reynaud & Maley, 1994)

$\Rightarrow$ Sea surface temperature linked with the oscillations of the Benguela current (e.g. Schefuss et al 2003)

Sea currents, Upwelling & Cool sea surface temperature

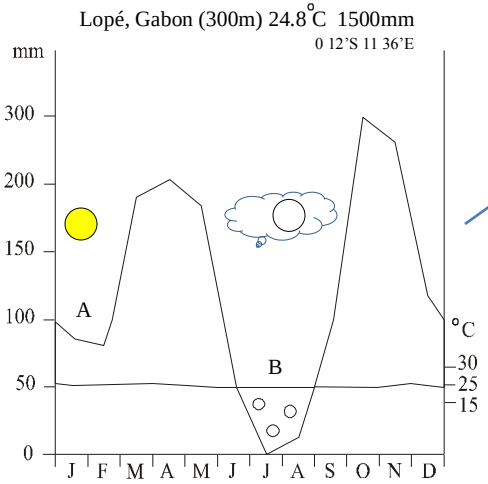




Wauthy 1983

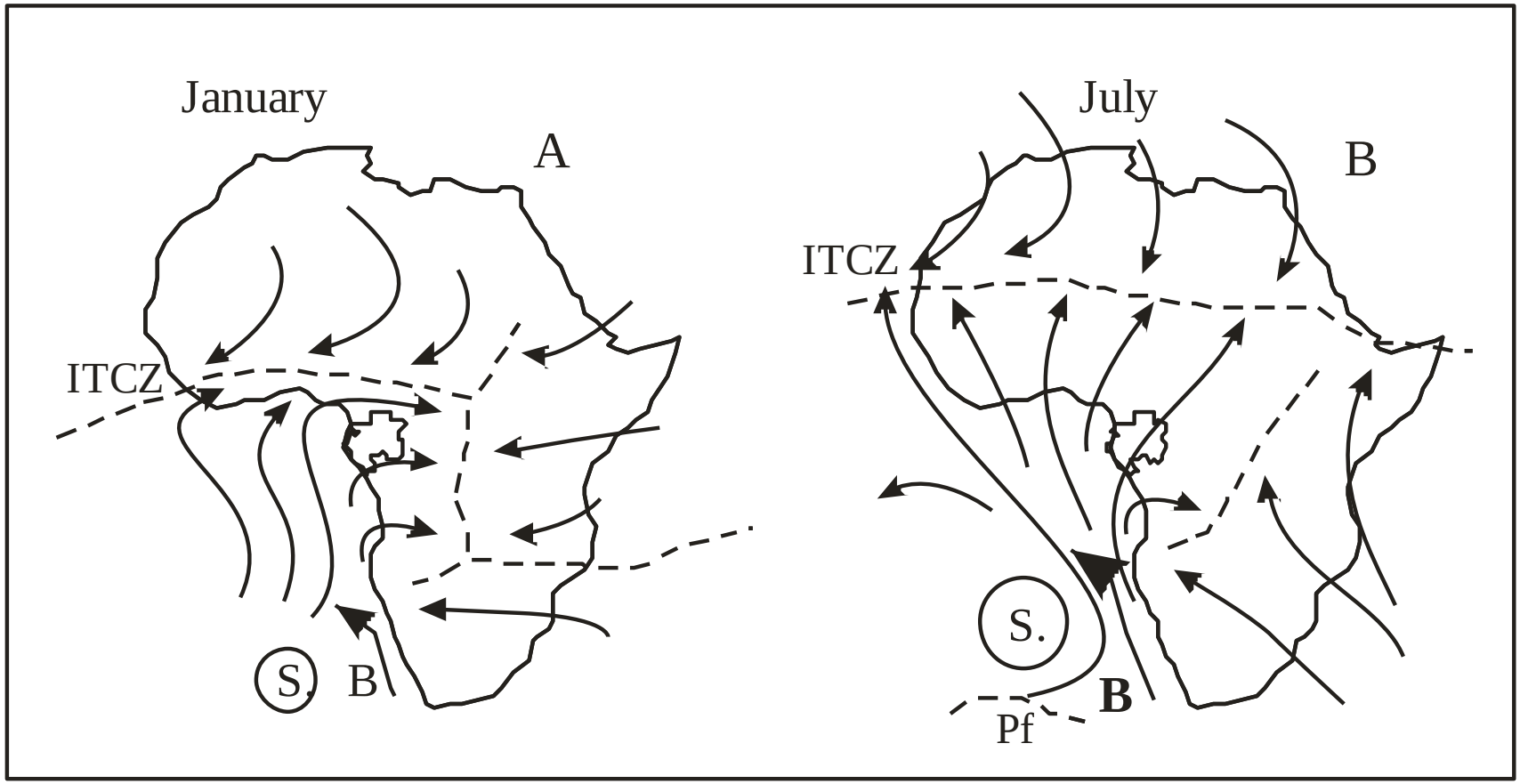
Regional drought stress

Cape Lopez

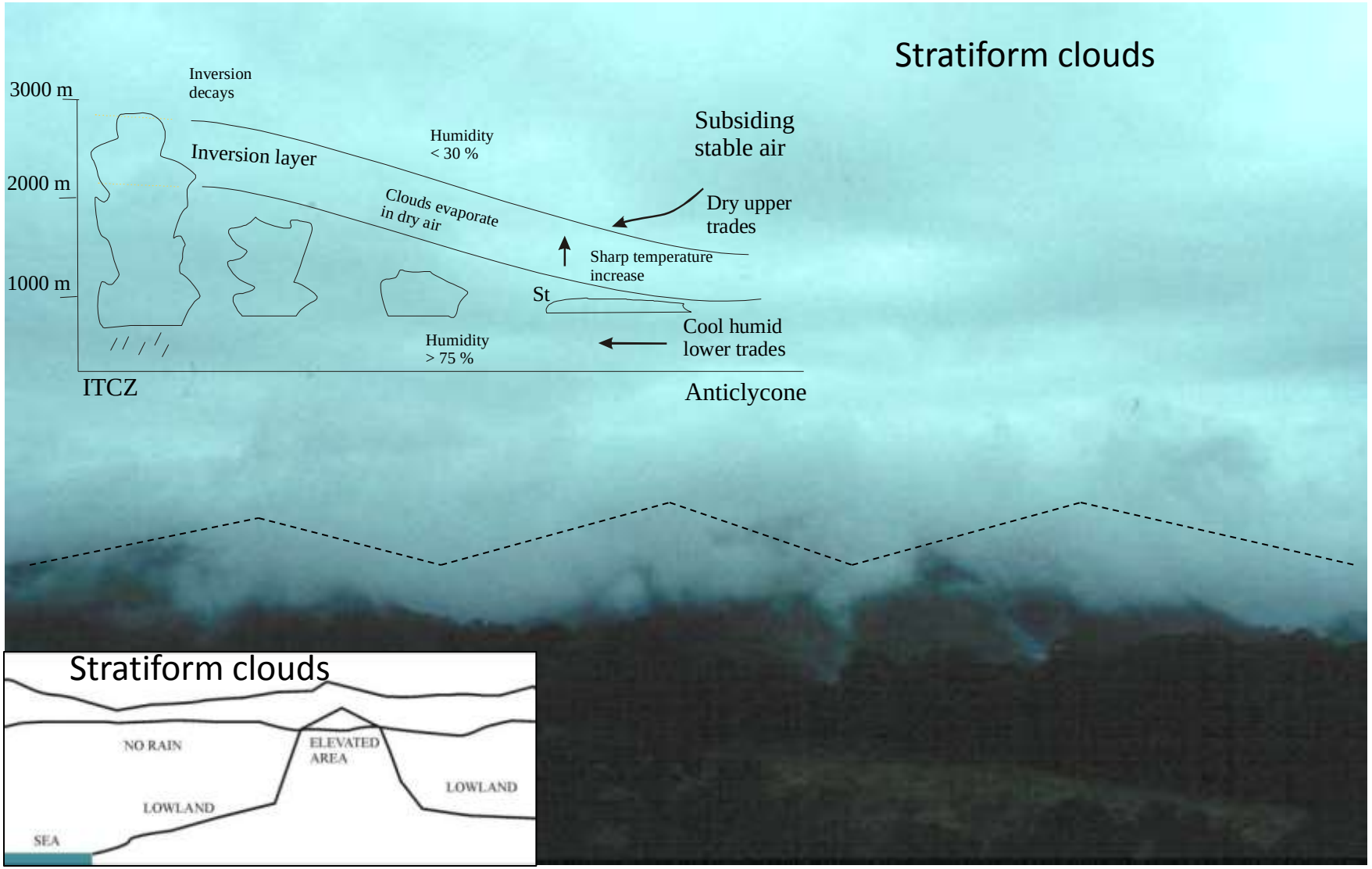


Bioclim; Hijmans et al. 2005

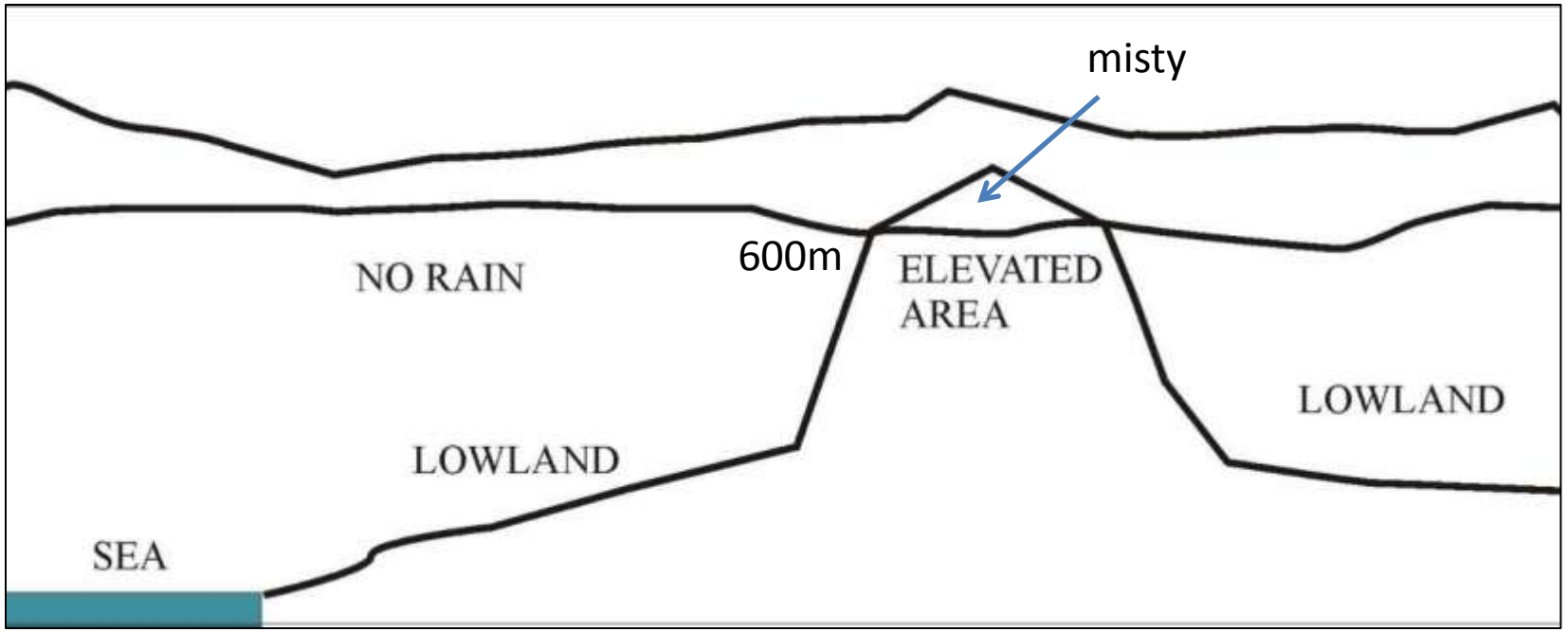
General circulation



Weather during the cool dry season

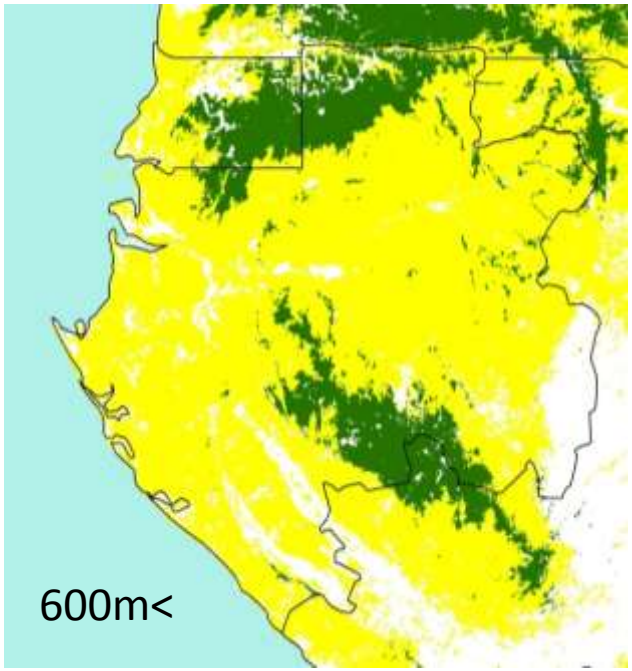


Local compensation from elevation



Cloud forest misty conditions provide local compensation for regional drought stress

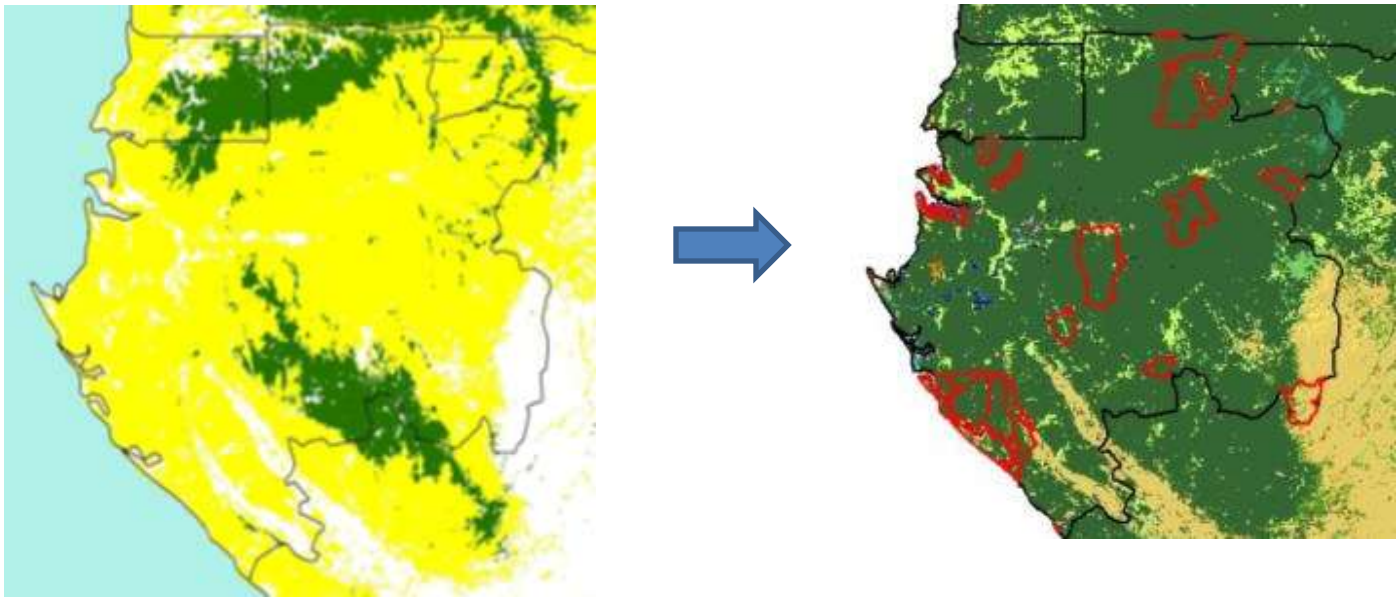
Reconstruction of forest refugia



Consequently forest dieback assumes the local extinction of drought sensitive plant species

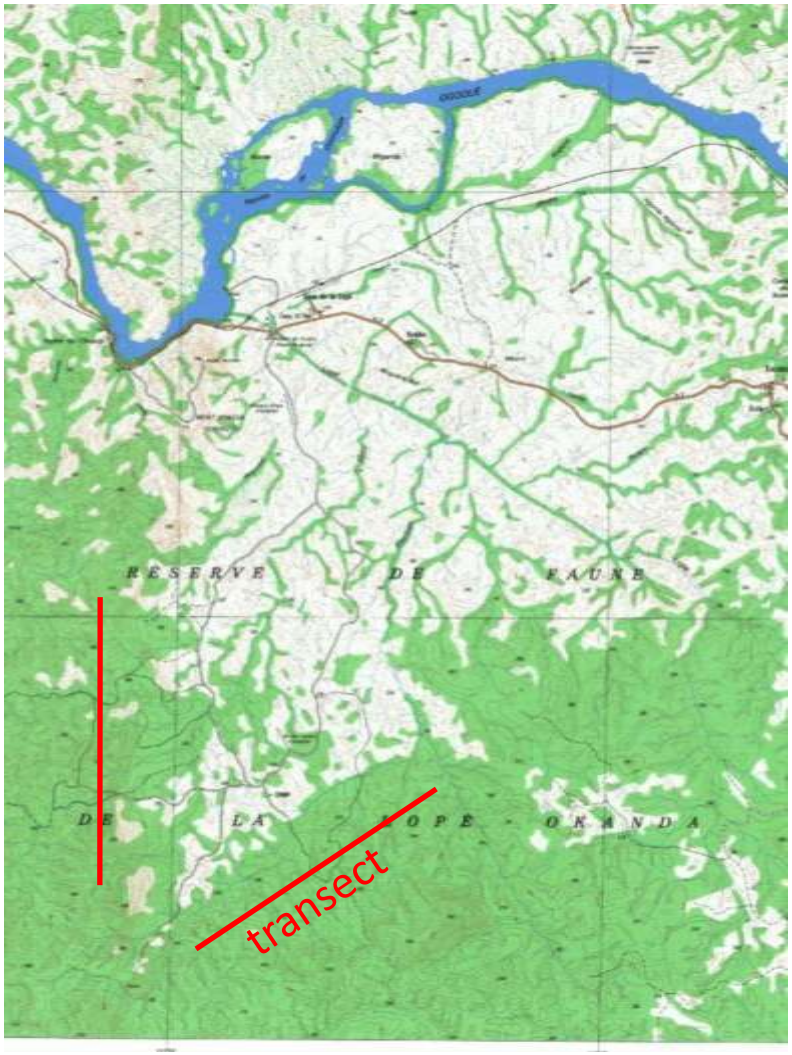
Current rainforest

Holocene expansion



- Slow dispersing trees such as the *Caesalpinioideae* are present outside forest refugia beyond their maximum Holocene expansion (Leal 2001)
- Forest in the coastal region did not originate from the elevated areas (Dauby et al. submitted)

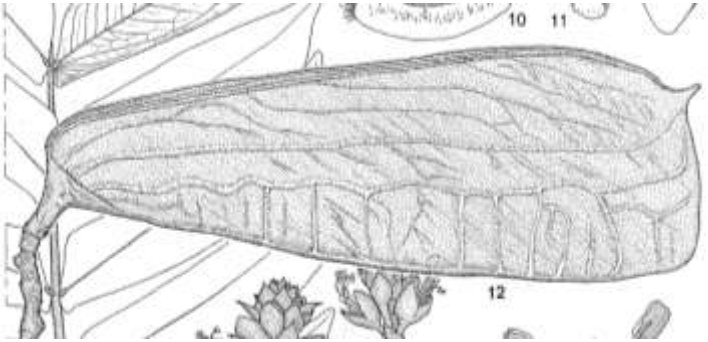
Lope forest savanna mosaic



Caesalps were rare, but present on 5km transects (White 1992)

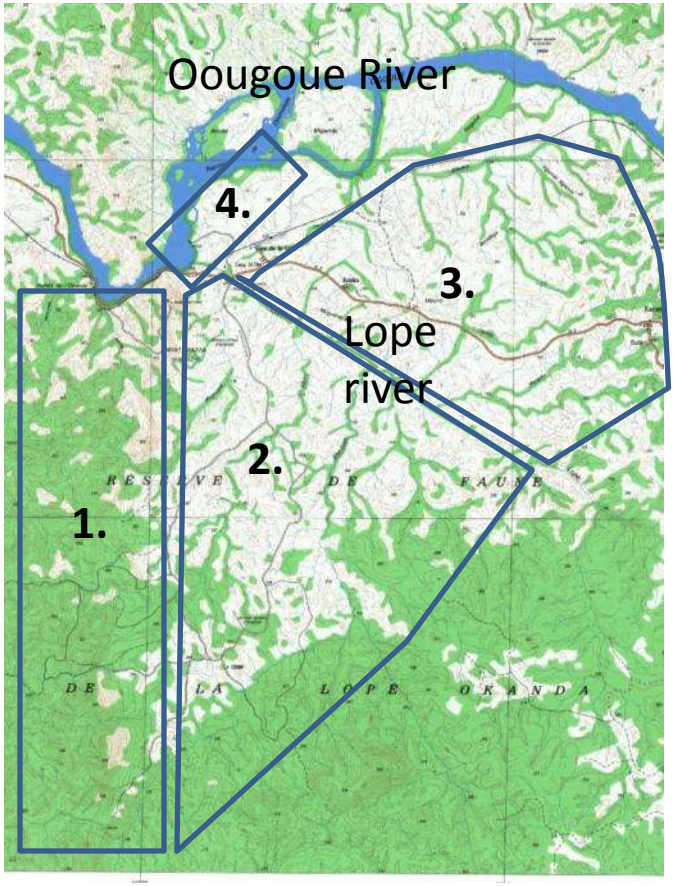
- Are these Caesalps drought resistant?
- If not, how did they reach Lope?
- Or were they able to survive in situ?

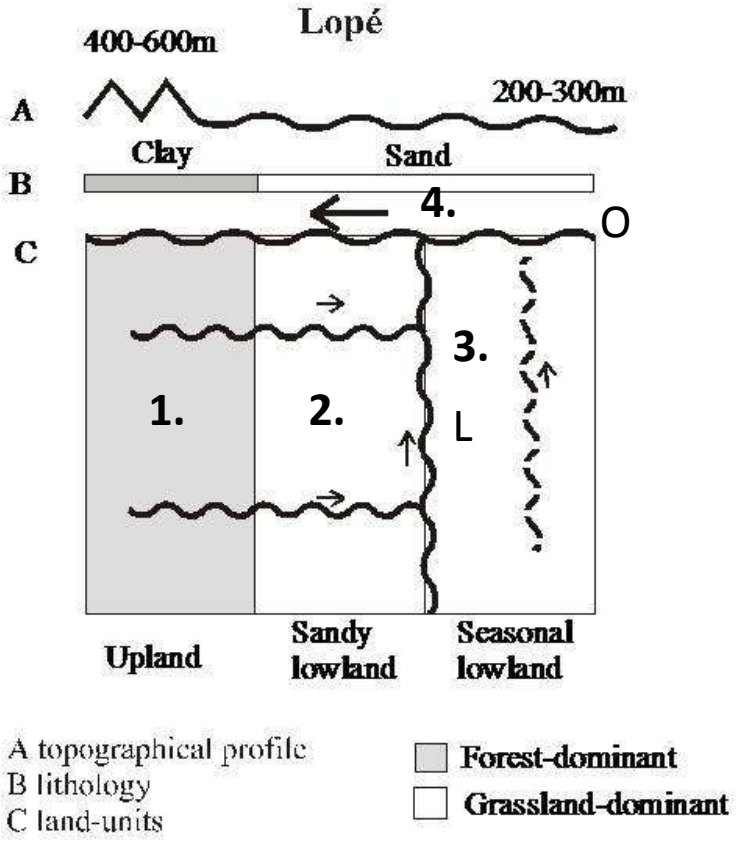
Caesalpinioideae



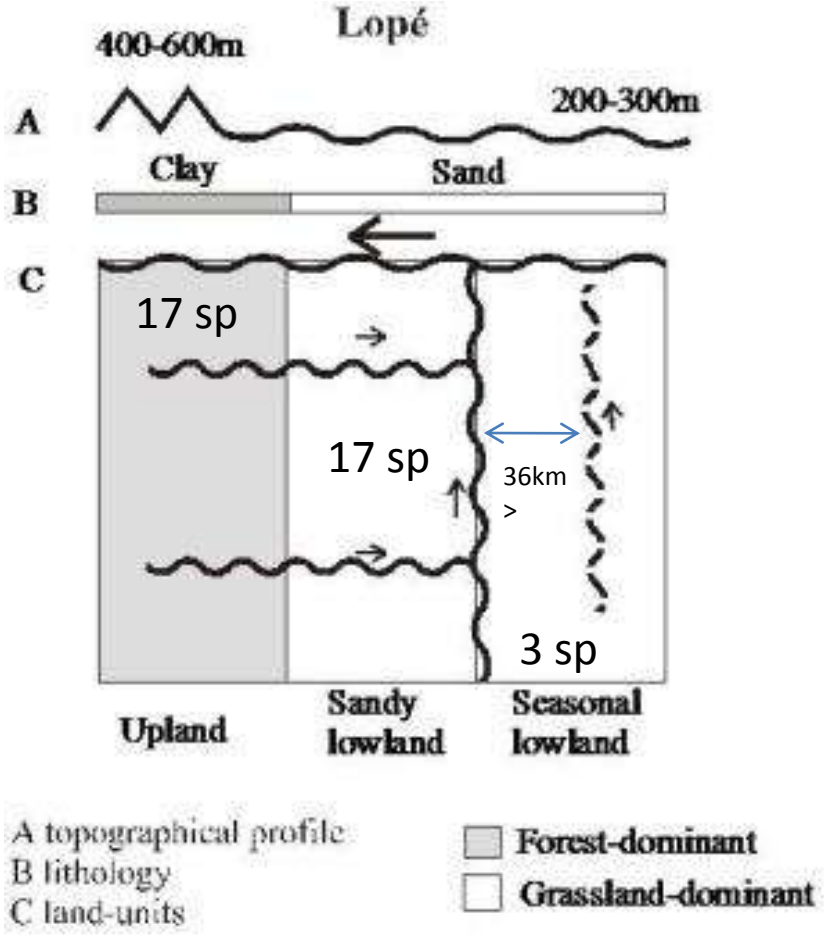
- Majority large (sub)canopy tree species
- Ballistic seed dispersal; max. 60m (Burgt, vande 1997)
- Characteristic for African lowland rain forest
- Maximum Holocene range expansion of 36 km (Leal 2001)

Landscape characteristics

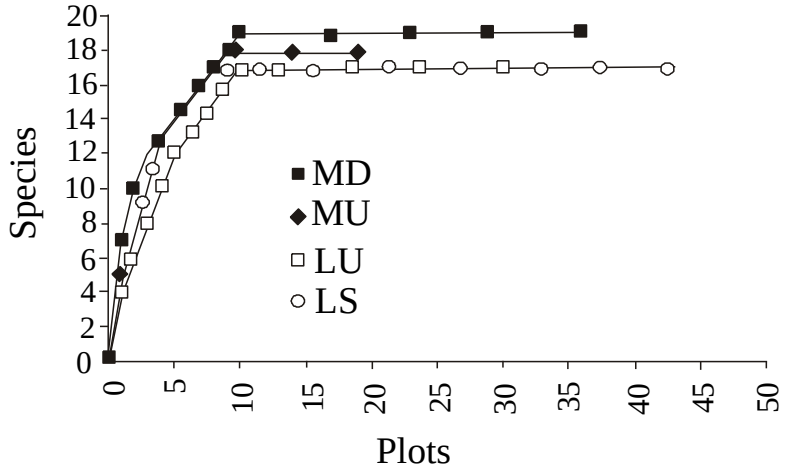




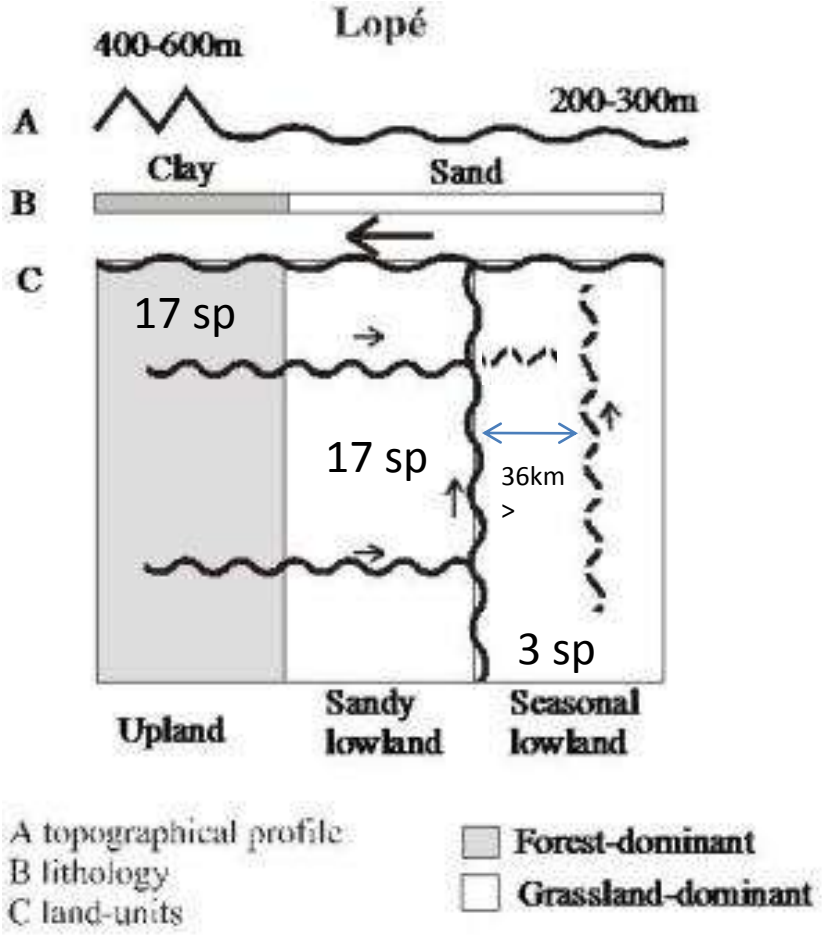
Caesalps diversity



Land-unit	#species
Upland	17
Lowland	17
Seasonal lowland	3
Oougoue RIver	4



Are Caesalps drought tolerant?

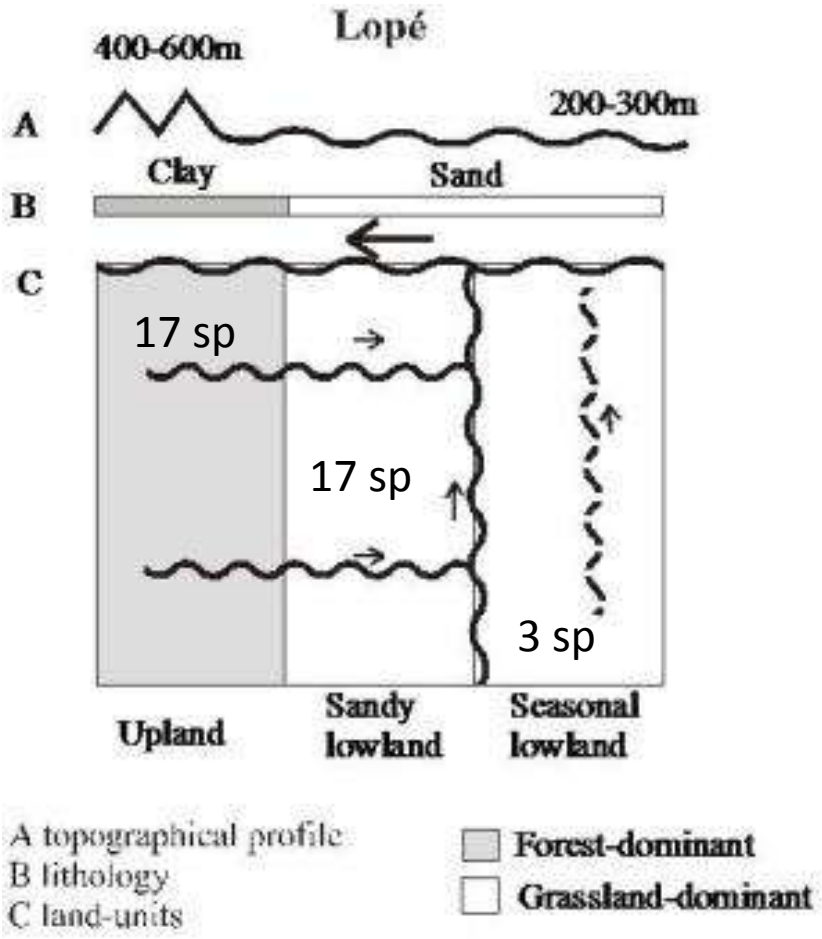


Land-unit	#species
Upland	17
Lowland	17
Seasonal lowland	3

- Dispersal is not an issue, as the seasonal streams are within the 36km maximum expansion

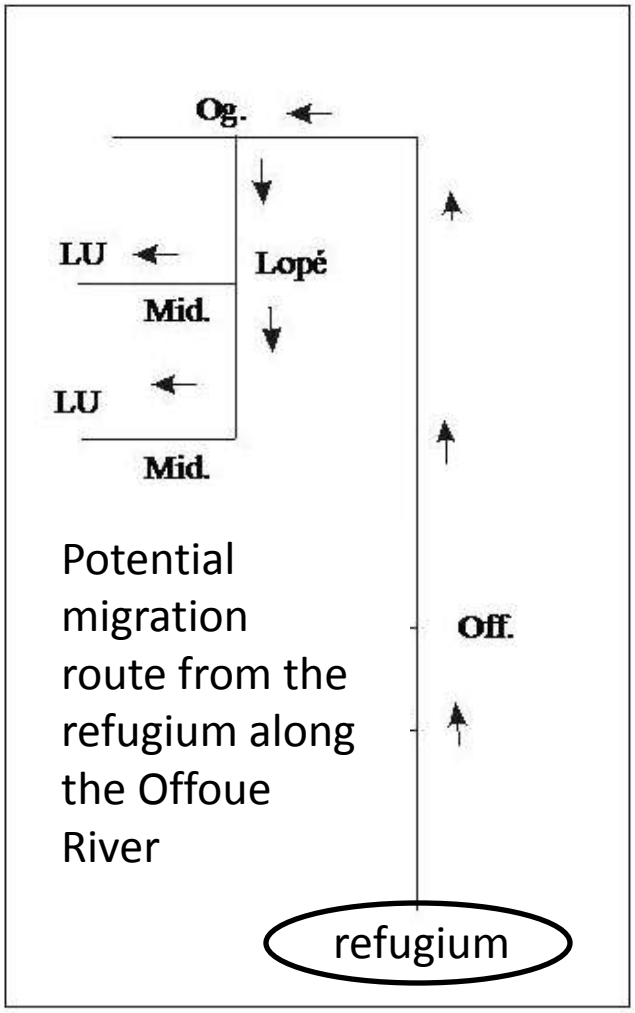
Conclusion: Only 3 species are drought tolerant the remaining 14 species were not.

Range Expansion



- Ballistic: 36km maximum expansion
- Occasional Long distance seed dispersal events by water down stream

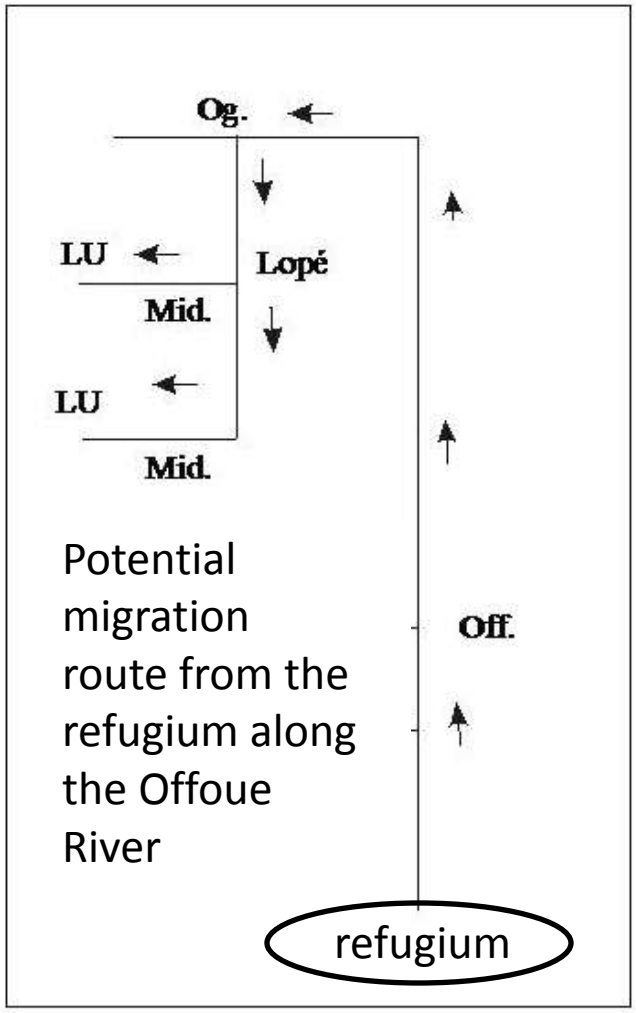
Down stream range expansion



Potential migration route from the refugium along the Offoue River

	Off.	Og.	Lopé	LU
Aph mar	1			
Hym fel	1			
Lib kla	1			
Gil pie	1			
Gil ogo	1			
Eur bat	1			
Jul pel	1			
Hym kla	1			
Aph dju		1	1	
Cyn sch		1		
Bai rob		1		
Gui dem		1		1
Cry sta			1	1
Neo ste			1	1
Pel dip			1	1
Sco zen			1	1
Cru gab			1	
Jul bri			1	
Tes dew			1	
Ber bra				
Ant mac				
Bra mil				1
Tet bif				1
Odd mic				1
Sin let				1
Jul pel				1
Ber aur				1
Hym pel				1
Tes ano				1
Aug let				1
Jul ser				1

Did the Caesalps come from the refugium?



Potential migration route from the refugium along the Offoue River

	Off.	Og.	Lopé	LU
Aph mar	1			
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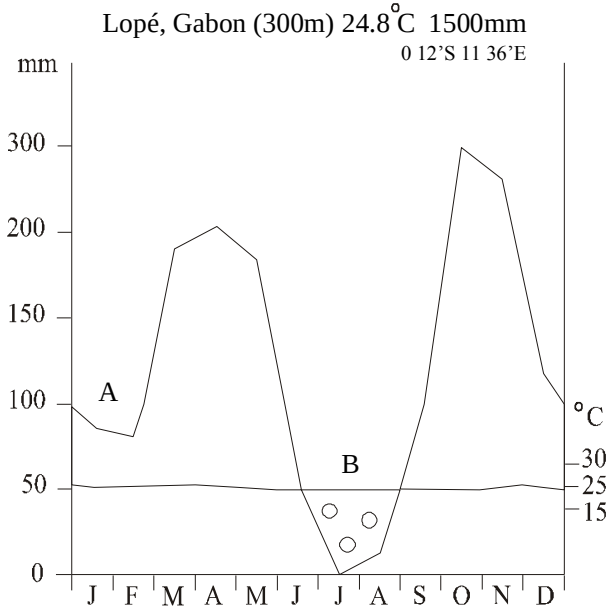
Aph dju		1	1	
Cyn sch		1		
Bai rob		1		
Gui dem		1		1
Cry sta			1	1
Neo ste			1	1
Pel dip			1	1
Sco zen			1	1
Cru gab			1	
Jul bri			1	
Tes dew			1	
Ber bra				
Ant mac				
Bra mil				1
Tet bif				1
Odd mic				1
Sin let				1
Jul pel				1
Ber aur				1
Hym pel				1
Tes ano				1
Aug let				1
Jul ser				1

- There is no overlap between the different segments of the potential migration route;
- If this was a potential route then more species along the Offoue should also occur in Lope

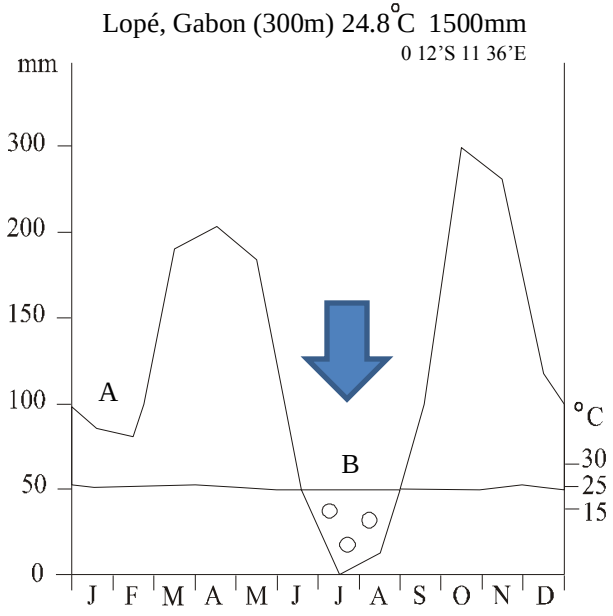
Conclusion: the Caesalps in Lope did not arrive from the nearest refugium

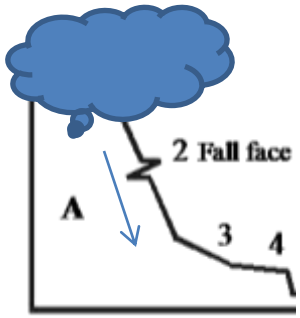
Did the Caesalps survive in situ?



- If so, how were they able to cope with the drought stress?
- The bottleneck for these Caesalps are the two dry seasons:
  - Cool dry season (b)
  - Hot dry season (a)

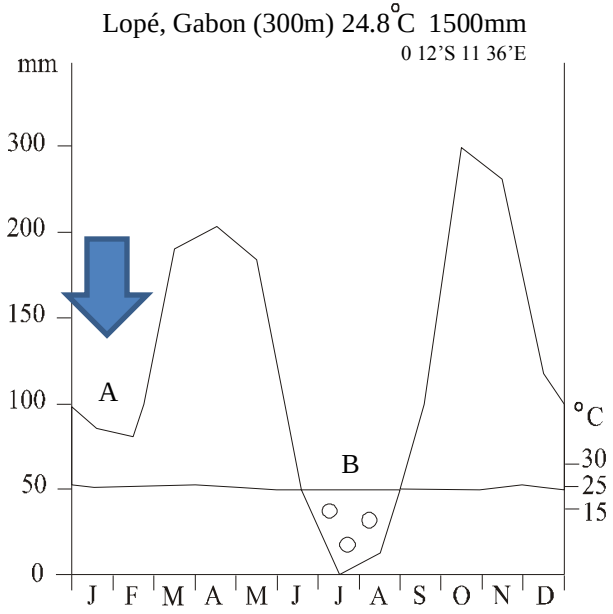
Cool dry season





- During the cool dry season drought stress is highest in the eastern lowland when streams dry up
- Western lowland stream remain permanent and daily maximum temperature remain moderate
- Upland is frequently shrouded in mist

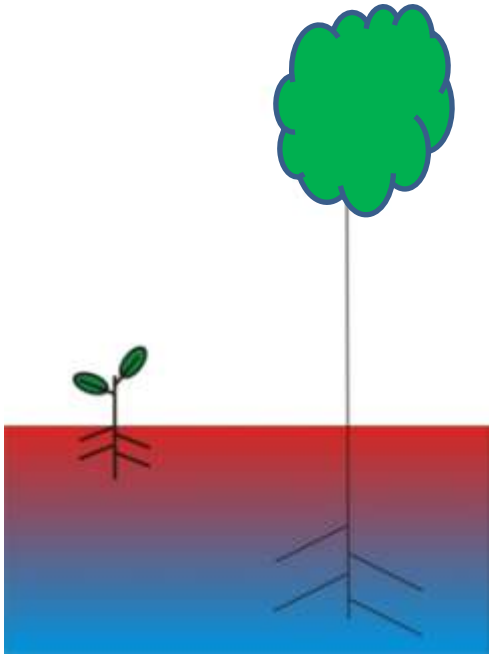
Hot dry season



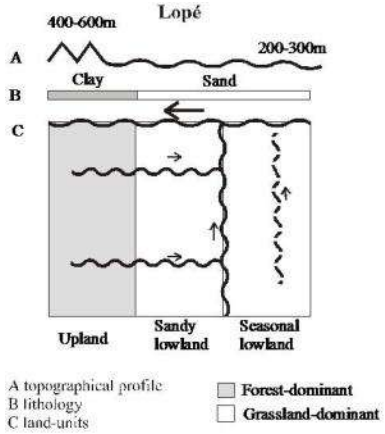
- During the hot dry season there is sufficient rainfall that even the streams in eastern lowland do not dry up
- In both lowlands daily maximum temperature are high
- Exposure to sunshine is high in both lowlands and upland summit

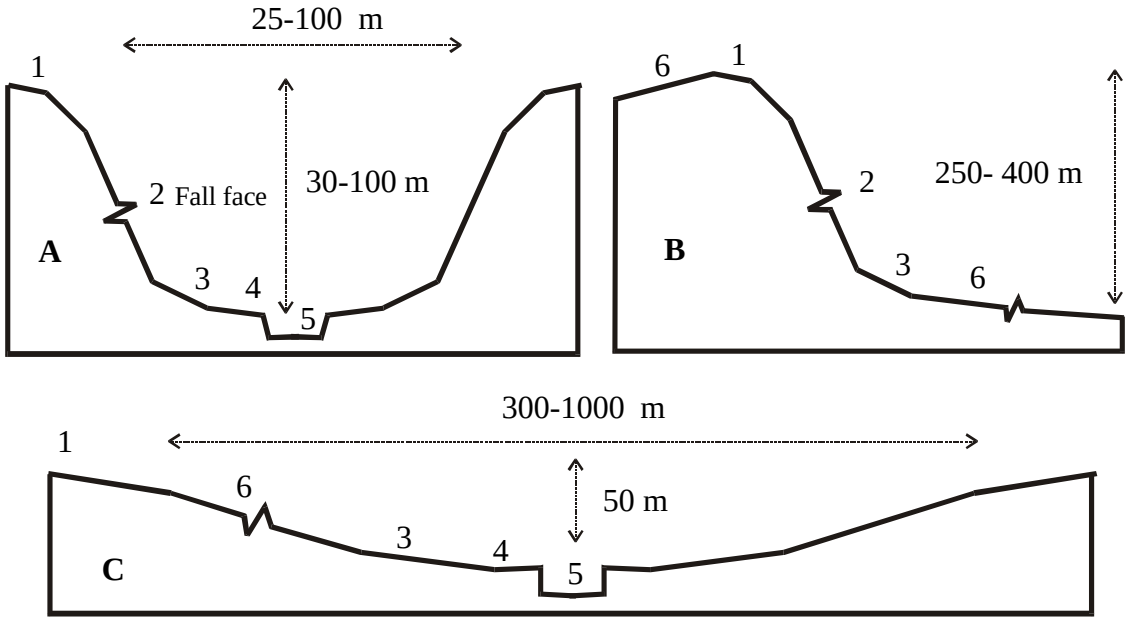
Evapotranspiration

During the hot dry season evapotranspiration is high and can only compensated by shade or sufficient soil moisture (MPa).



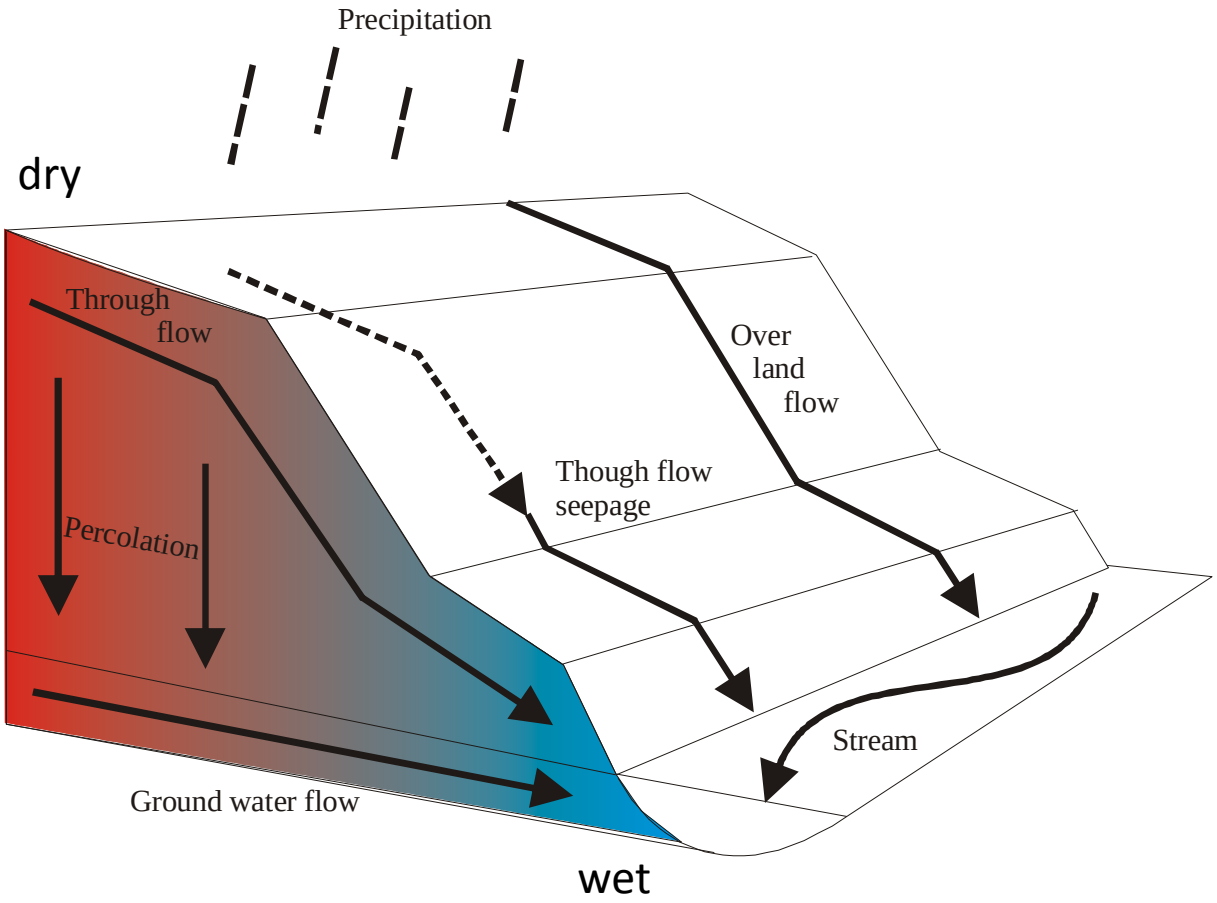
Geomorphology



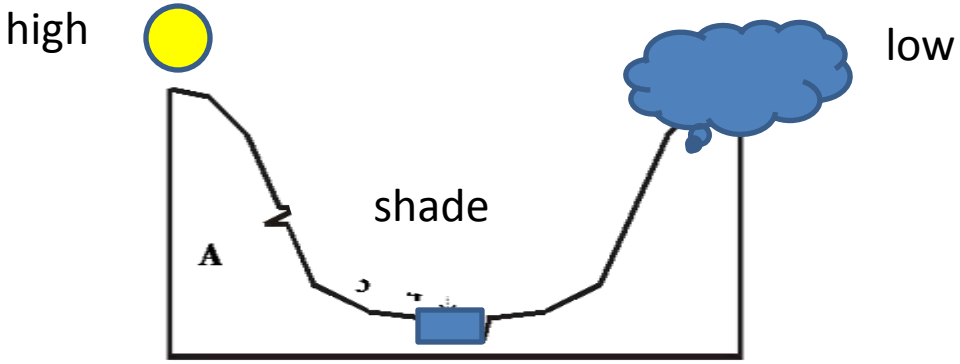


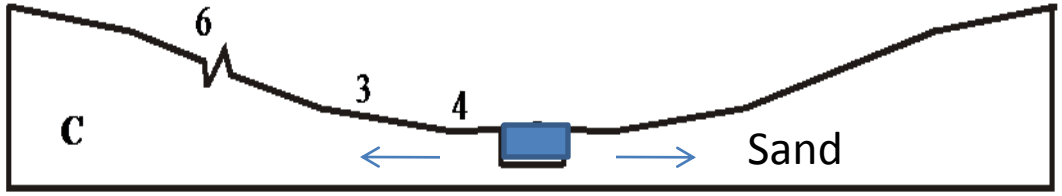
Redistribution, drains and capture of moisture

Hill slope hydrology



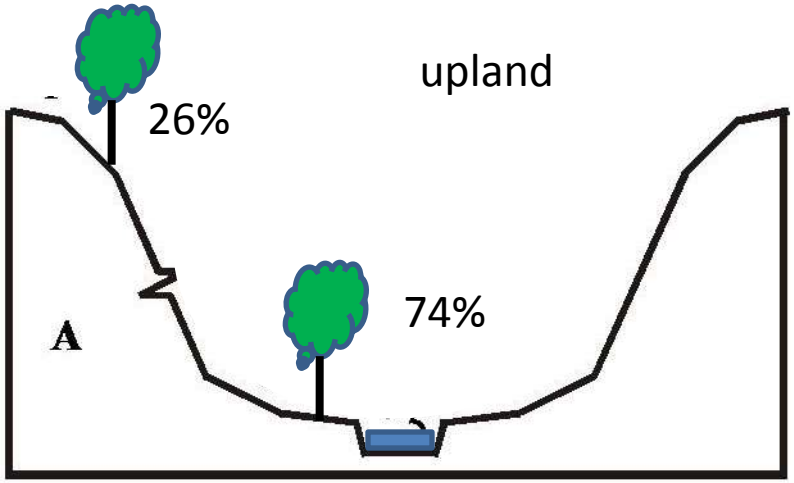
Local compensation

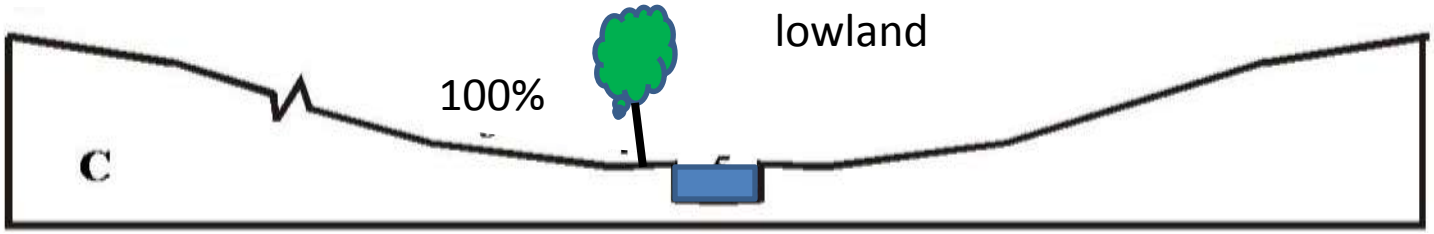




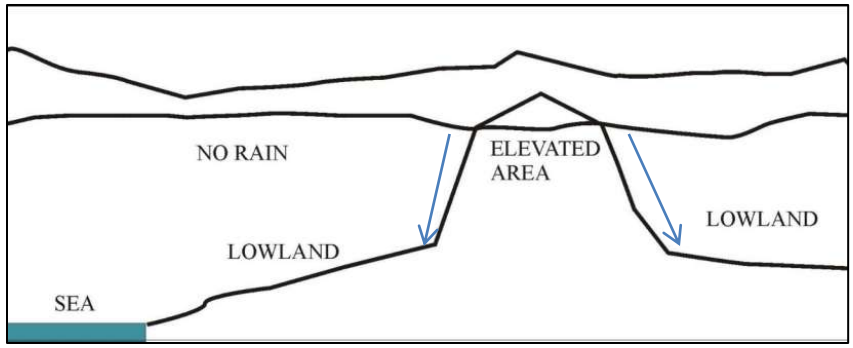
seepage

Caesalp distribution within the catchment





Elevation and ruggedness

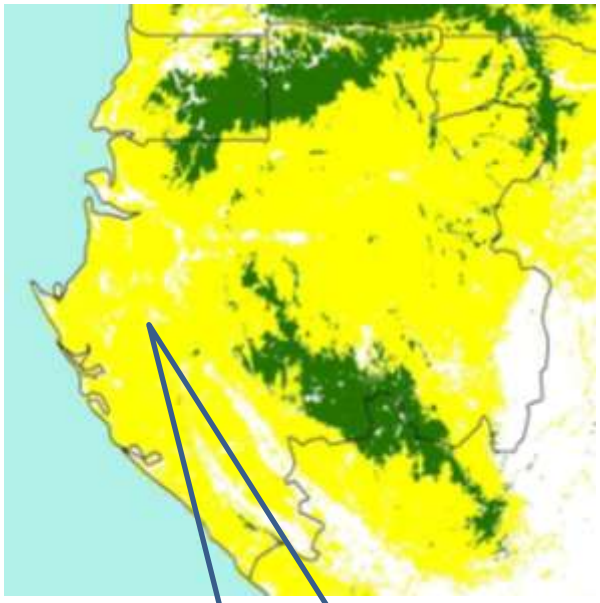


Rugged areas in Gabon

Hills

- intercept moisture from the mist and provide running water in the adjacent lowland
- provide shade reducing the effect of evapotranspiration

Conclusion



Specially local compensation provided by ruggedness will be important with future climate change

Further observations

- **climate change-vegetation models** will **not** be able to **accurately** predict **future** rainforest shifts since they do not take into account the effect of local compensation

- **Identifying** the climatically stable or **resilient forest** will help **conservation** become more **effective**

Thank you for your attention

Questions?