Salut Dominique et Aurelien,

J'ai essayé de fournir ci-dessous une description des variables générées. J'ai également rajouté des liens avec plus de détails sur l
peu de biblio à la fin pour se familiariser avec ces questions de dynamiques de transition forêt savane.

N'hésite pas si tu as des questions.

A+

Le Bien.

Environnemental variables:

1- fire_freq = 250-m yearly fire frequency (Fire/year) from MODIS Fire_cci Burned Area Pixel Product from 2001-2020. Each value
that pixel. Maxed pixel values from MODIS will have NA meaning there were no fire data for that given pixel.
2- mean_precip = Mean annual precipitation (MAP, mm/year) from ERA5 Monthly Aggregates (~ 30km resolution)
3- cv_rainfall = MAP variance (MAP, mm/year)
4- eff_rainfall = Effective rainfall (mm/year) is equal to the difference between MAP and the evapotranspiration.
5- mean_temp = Mean temperature (¤C)
6- temp_range = Temperature range (¤C)
7- ecoregion = The RESOLVE Ecoregions dataset from the WWF, updated in 2017. We focused on Tropical & Subtropical Grasslar
by MODIS canopy cover product).

Vegetation structure variables (see more details about GEDI here https://gedi.umd.edu/mission/technology/):
1- GEDI RH98 = canopy height measured from best quality filtered shots (25 m resolution) over savanna. We only considered pix
sure that we only consider data from woodlands and savanna.
2- GEDI canopy cover = proportion of the canopy between 5-10 m from the ground for each 25 m GEDI shot. This was extracted
https://developers.google.com/earth-engine/datasets/catalog/LARSE_GEDI_GEDI02_B_002_MONTHLY#description)

The GEDI data were aggregated from 25 m to 250 m resolution using the average values in order to match the resolution of the fi

https://doi.org/10.1002/fee.2585

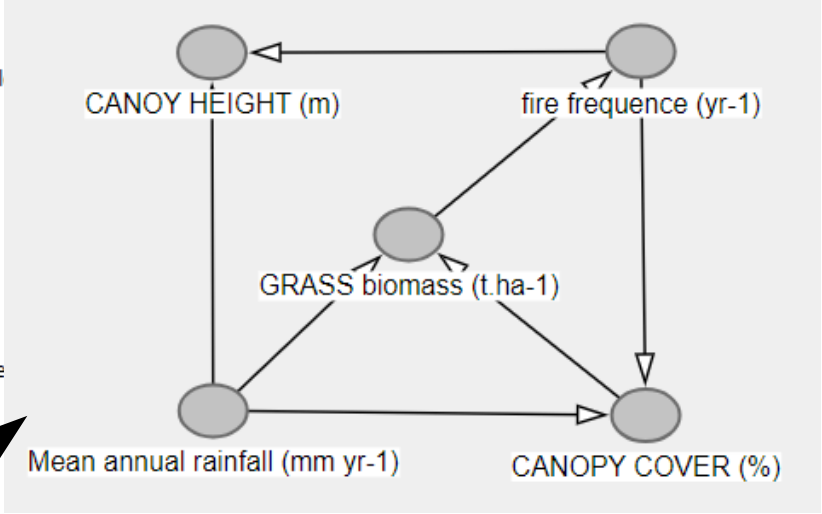
Sankaran, M., Hanan, N., Scholes, R. et al. Determinants of woody cover in African savannas. Nature 438, 846–849 (2005). https://d

Lehmann, C.E.R., Archibald, S.A., Hoffmann, W.A. and Bond, W.J. (2011), Deciphering the distribution of the savanna biome. New P

Marina Hirota et al. ,Global Resilience of Tropical Forest and Savanna to Critical Transitions. Science334,232-235(2011). DOI:10.112

Caroline E. R. Lehmann et al. ,Savanna Vegetation-Fire-Climate Relationships Differ Among Continents. Science 343, 548-552 (201

Higgins, S. I., Conradi, T., Kruger, L. M., O'Hara, R. B., & Slingsby, J. A. (2023). Limited climatic space for alternative ecosystem state



Testable implications

The model implies the following conditional independences:

- CANOPY COVER (%) ⊥ CANOY HEIGHT (m) | Mean annual rainfall (mm yr-1), fire frequence (yr-1)
- CANOY HEIGHT (m) ⊥ GRASS biomass (t.ha-1) | Mean annual rainfall (mm yr-1), fire frequence (yr-1)

Model code

```
dag {
bb="0,0,1,1"
"CANOPY COVER (%)"
[pos="0.528,0.613"]
"CANOY HEIGHT (m)"
[pos="0.173,0.300"]
"GRASS biomass (t.ha-1)"
[pos="0.334,0.457"]
"Mean annual rainfall (mm yr-
1)" [pos="0.174,0.609"]
```

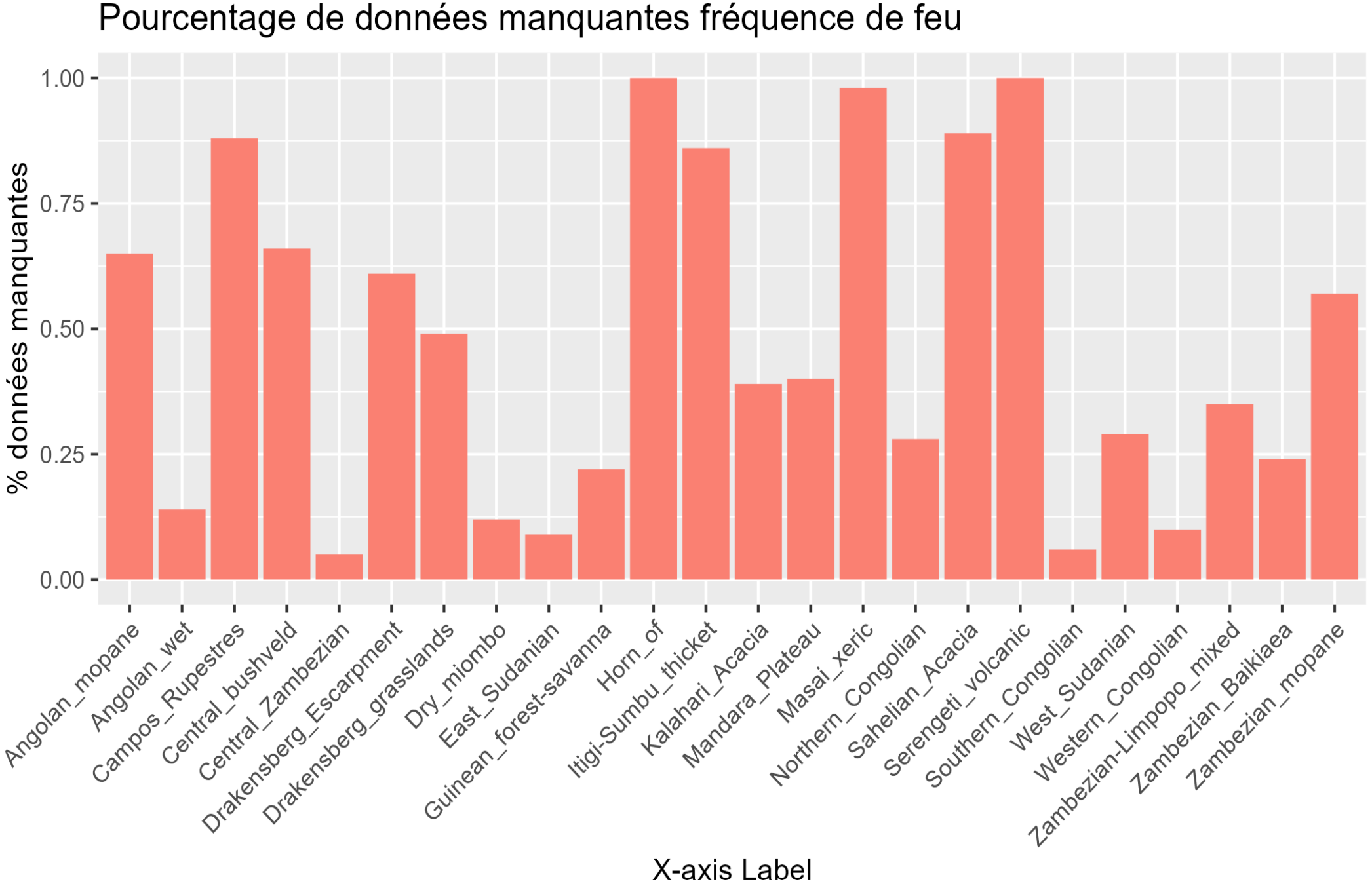
Summary

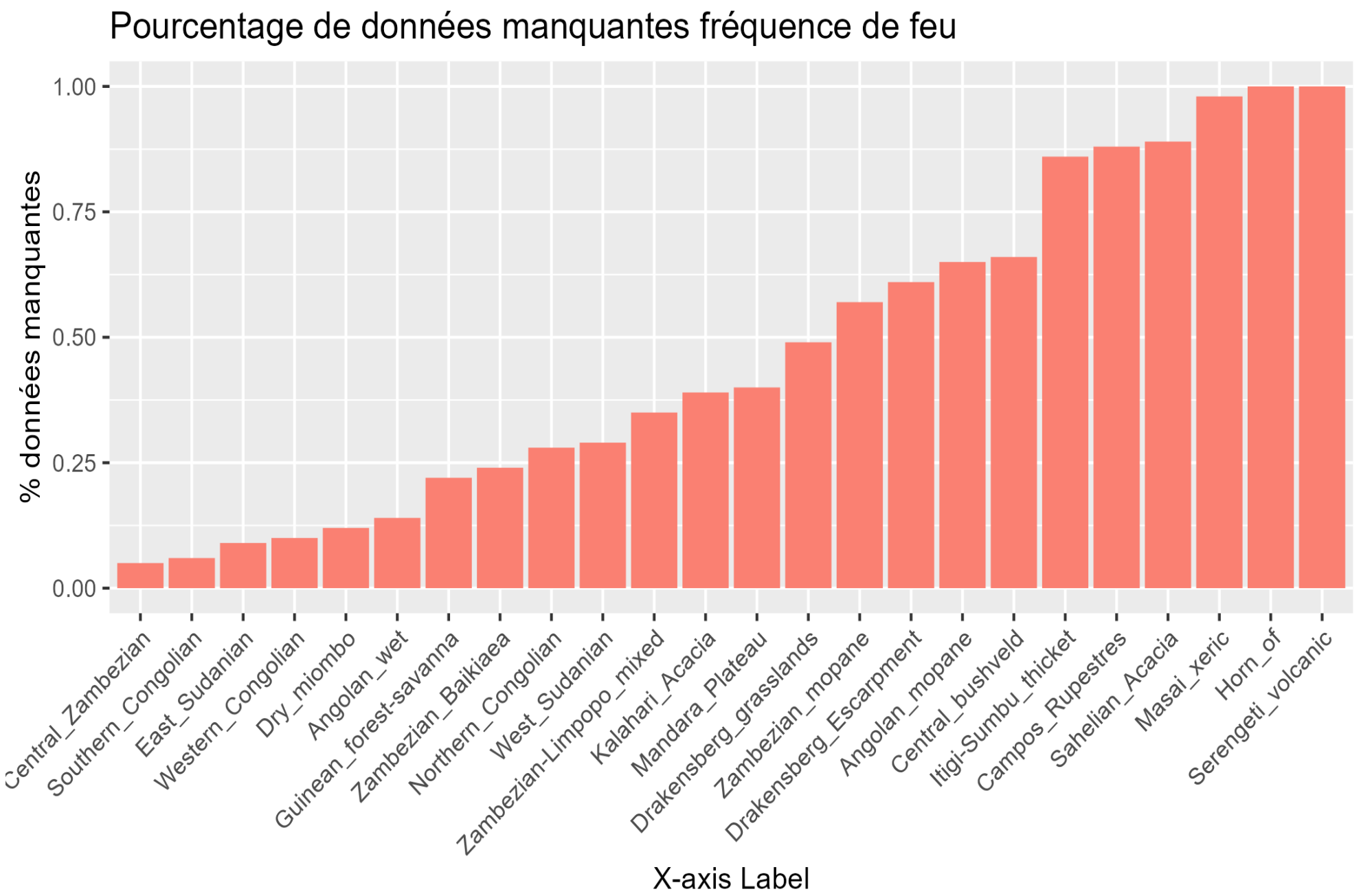
Model contains cycle: CANOPY COVER (%)→GRASS biomass (t.ha-1)→fire frequence (yr-1)→CANOPY COVER (%)

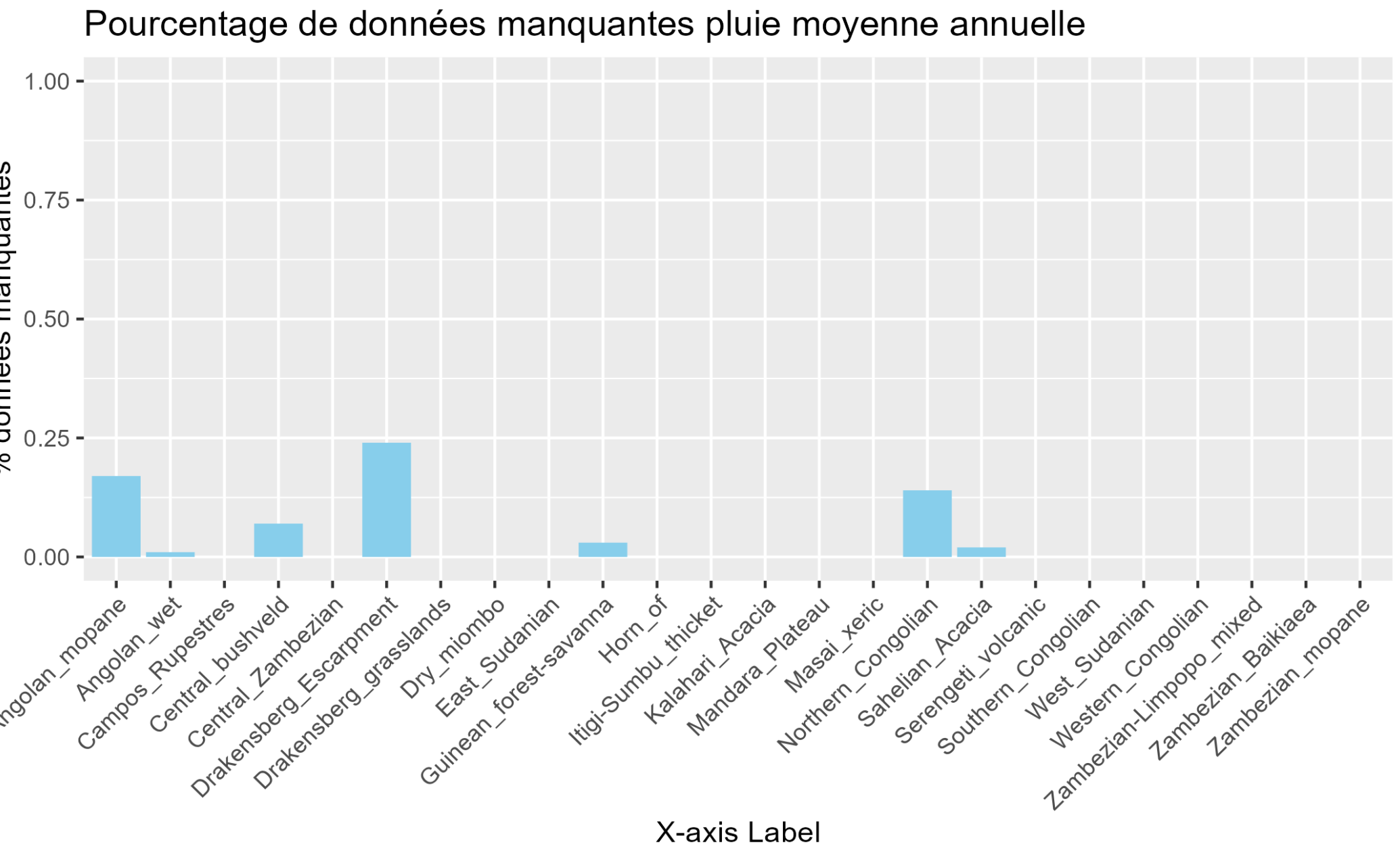
```
> dir()
 [1] "Angolan_mopane.fst"           "Angolan_wet.fst"              "Campos_Rupestres.fst"
 [4] "Central_bushveld.fst"         "Central_Zambezian.fst"        "Drakensberg_Escarpment.fst"
 [7] "Drakensberg_grasslands.fst"   "Dry_miombo.fst"               "East_Sudanian.fst"
[10] "Guinean_forest-savanna.fst"   "Horn_of.fst"                  "Itigi-Sumbu_thicket.fst"
[13] "Kalahari_Acacia.fst"          "Mandara_Plateau.fst"          "Masai_xeric.fst"
[16] "Northern_Congolian.fst"       "Sahelian_Acacia.fst"          "Serengeti_volcanic.fst"
[19] "Southern_Congolian.fst"       "West_Sudanian.fst"            "Western_Congolian.fst"
[22] "Zambezian-Limpopo_mixed.fst" "Zambezian_Baikiaea.fst"       "Zambezian_mopane.fst"
```

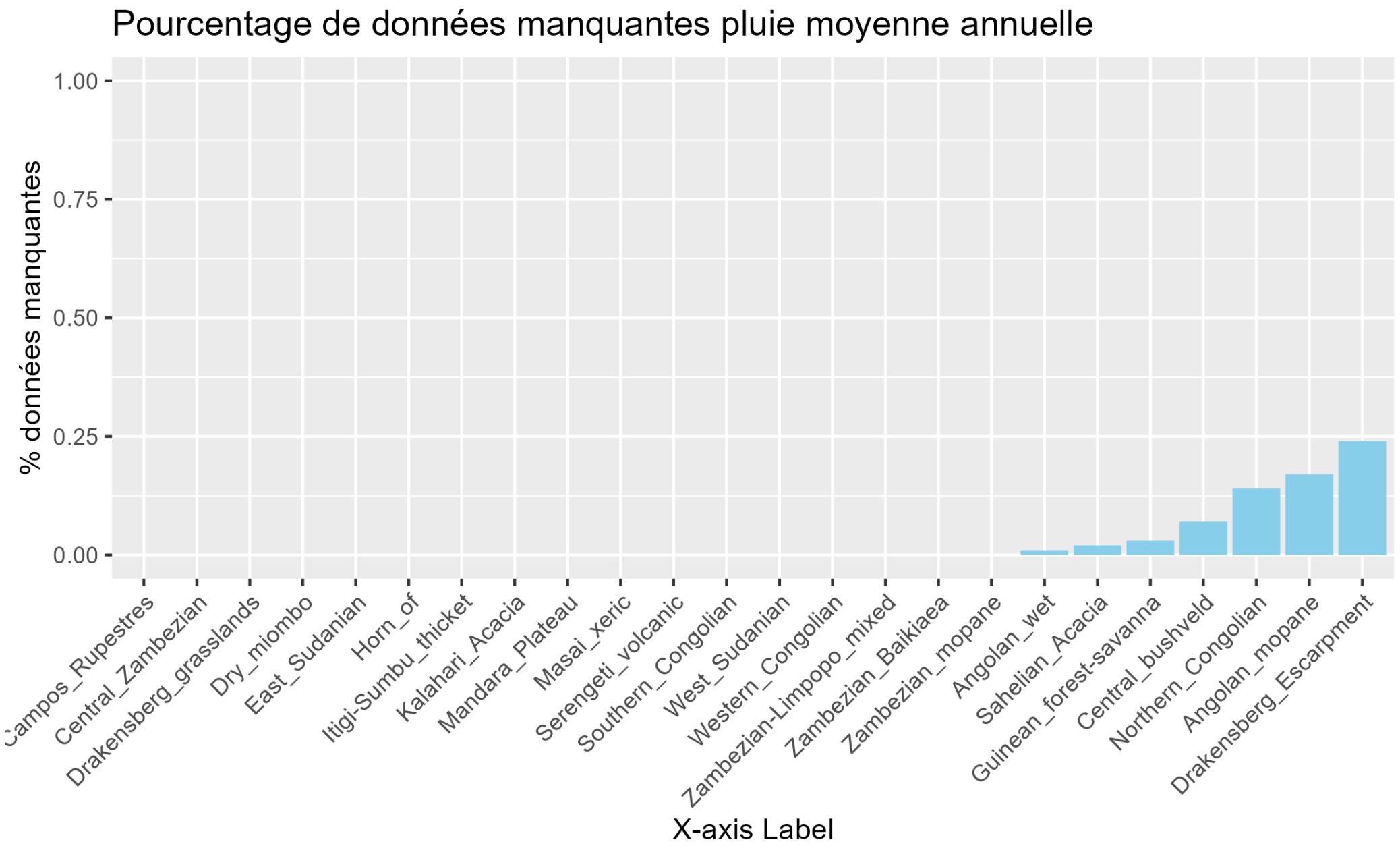
Filter

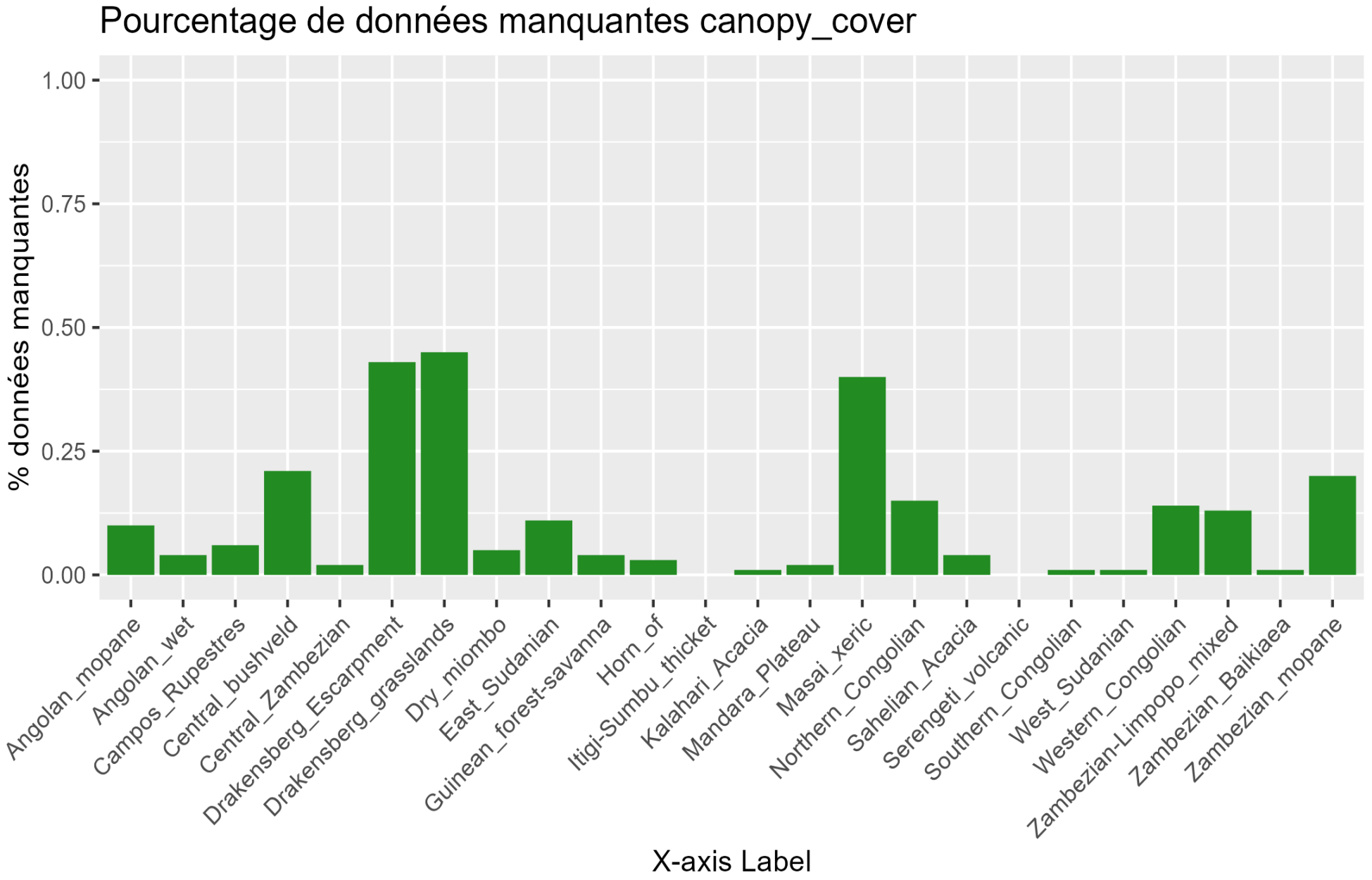
	x	y	rh98	canopy_cover	fire_freq	mean_precip	cv_rainfall	eff_rainfall	mean_temp	temp_range	ecoregion
1	37.00048	14.26637	5.982667	0.028192833	*NA*	723.4141	0.1426200	408.4453	27.65563	39.20422	East_Sudanian
2	37.00048	14.26412	3.955000	0.009793250	*NA*	723.4141	0.1426200	408.4453	27.65563	39.20422	East_Sudanian
3	37.00048	14.26188	5.516917	0.036079351	*NA*	723.4141	0.1426200	408.4453	27.65563	39.20422	East_Sudanian
4	37.00273	14.26188	2.362500	0.000000000	*NA*	736.2011	0.1401428	421.2323	27.65563	39.20422	East_Sudanian
5	37.00048	14.25963	7.982583	0.067758726	0.5789474	723.4141	0.1426200	408.4453	27.65563	39.20422	East_Sudanian
6	37.00273	14.25739	6.243066	0.051658304	0.5789474	736.2011	0.1401428	421.2323	27.65563	39.20422	East_Sudanian
7	37.00498	14.25739	3.649250	0.005104925	0.4210526	736.2011	0.1401428	421.2323	27.65563	39.20422	East_Sudanian
8	37.00273	14.25514	5.696667	0.027369666	0.5789474	736.2011	0.1401428	421.2323	27.65563	39.20422	East_Sudanian
9	37.00498	14.25514	4.800551	0.021938594	0.2631579	736.2011	0.1401428	421.2323	27.65563	39.20422	East_Sudanian
10	37.00498	14.25289	4.807361	0.023310125	0.5789474	736.2011	0.1401428	421.2323	27.65563	39.20422	East_Sudanian
11	37.00048	14.25065	7.596666	0.051529834	0.6315789	723.4141	0.1426200	408.4453	27.65563	39.20422	East_Sudanian
12	37.00498	14.25065	6.462917	0.029497749	0.6315789	736.2011	0.1401428	421.2323	27.65563	39.20422	East_Sudanian
13	37.00722	14.25065	8.828167	0.062860383	0.6315789	736.2011	0.1401428	421.2323	27.65563	39.20422	East_Sudanian
14	37.00048	14.24840	8.148000	0.070121550	0.7368421	760.8568	0.1408722	461.4591	27.00262	38.99936	East_Sudanian
15	37.00273	14.24840	10.210000	0.149196750	0.6315789	769.7281	0.1392486	470.3304	27.00262	38.99936	East_Sudanian
16	37.00498	14.24840	7.349333	0.060823599	0.6842105	769.7281	0.1392486	470.3304	27.00262	38.99936	East_Sudanian
17	37.00048	14.24616	6.503056	0.065599903	0.7368421	760.8568	0.1408722	461.4591	27.00262	38.99936	East_Sudanian
18	37.00273	14.24616	6.890729	0.073749000	0.6842105	769.7281	0.1392486	470.3304	27.00262	38.99936	East_Sudanian
19	37.00722	14.24616	3.480000	0.000000000	0.6842105	769.7281	0.1392486	470.3304	27.00262	38.99936	East_Sudanian
20	37.00947	14.24616	5.408594	0.025604832	0.7368421	769.7281	0.1392486	470.3304	27.00262	38.99936	East_Sudanian
21	37.00048	14.24391	5.723690	0.035549358	0.6842105	760.8568	0.1408722	461.4591	27.00262	38.99936	East_Sudanian
22	37.00273	14.24391	3.923333	0.002112929	0.6842105	769.7281	0.1392486	470.3304	27.00262	38.99936	East_Sudanian
23	37.00498	14.24391	3.820000	0.001467042	0.7368421	769.7281	0.1392486	470.3304	27.00262	38.99936	East_Sudanian

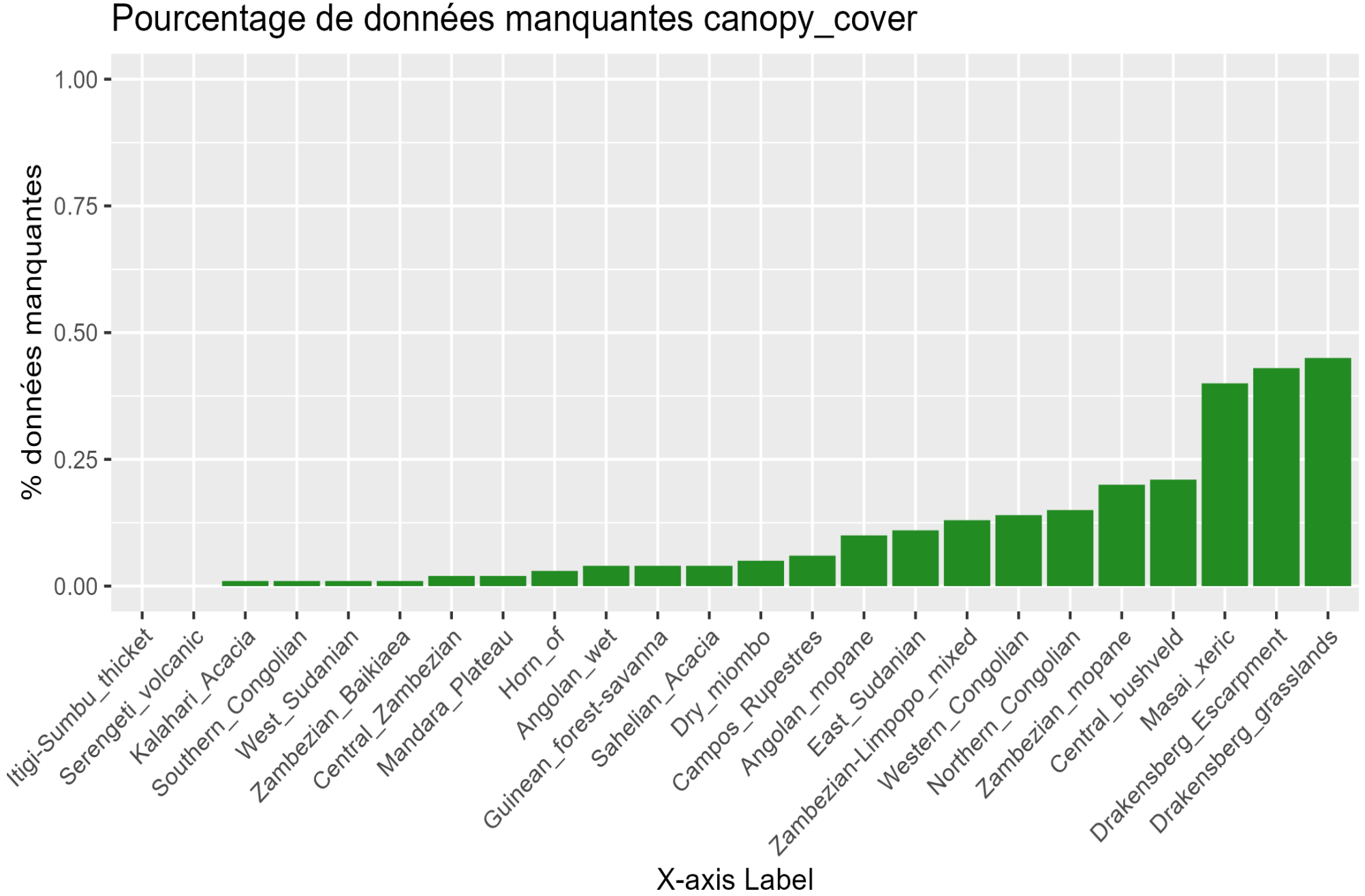

Pourcentage de données manquantes fréquence de feu
% données manquantes
1.00
0.75
0.50
0.25
0.00
Angolan_mopane
Angolan_wet
Campos_Rupestres
Central_bushveld
Central_Zambezian
Drakensberg_Escarpment
Drakensberg_grasslands
Dry_miombo
East_Sudanian
Guinean_forest-savanna
Horn_of
Itigi-Sumbu_thicket
Kalahari_Acacia
Mandara_Plateau
Masai_xeric
Northern_Congolian
Sahelian_Acacia
Serengeti_volcanic
Southern_Congolian
West_Sudanian
Western_Congolian
Zambezian-Limpopo_mixed
Zambezian_Baikiaea
Zambezian_mopane
X-axis Label

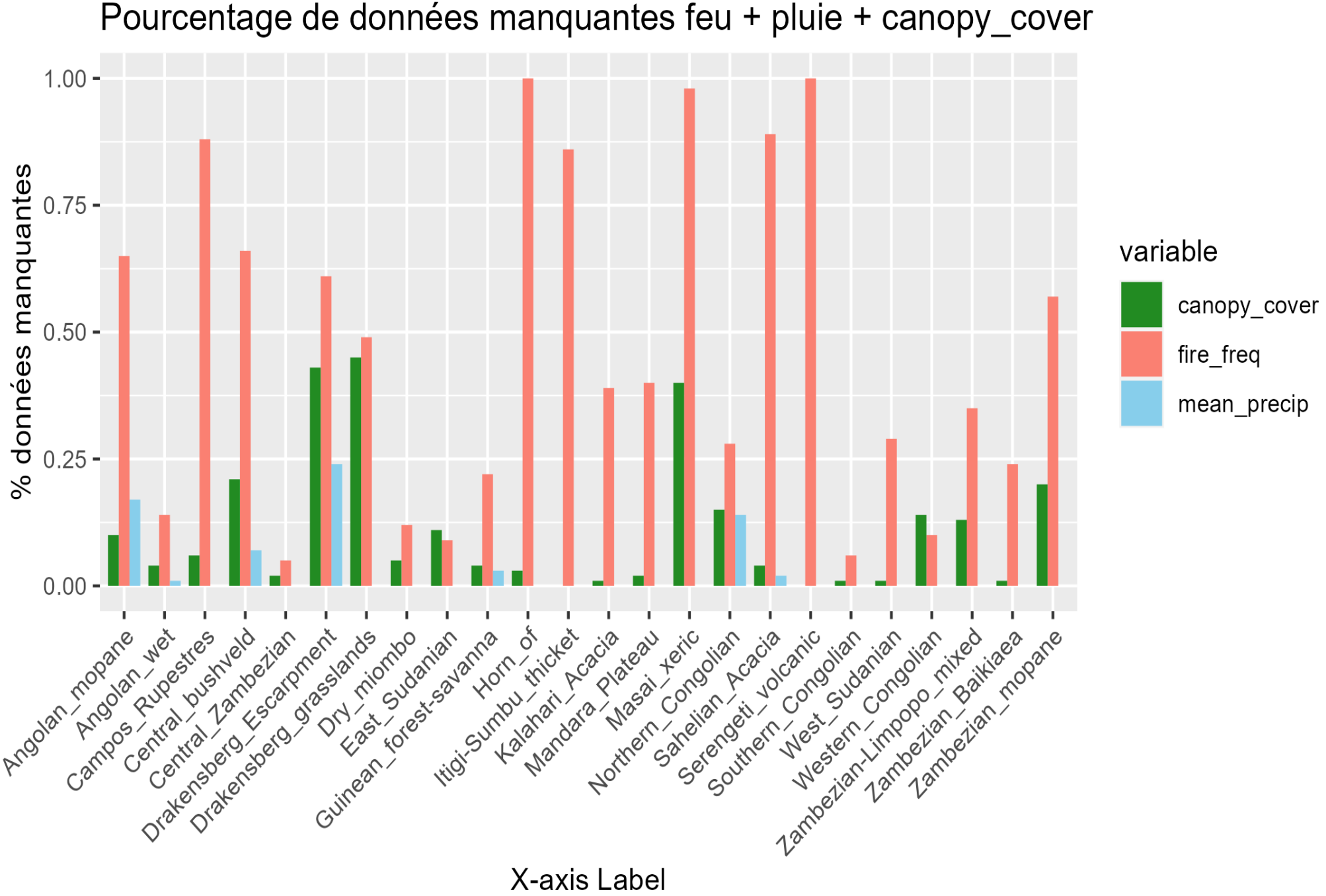

Pourcentage de données manquantes fréquence de feu
% données manquantes
1.00
0.75
0.50
0.25
0.00
Central_Zambezian
Southern_Congolian
East_Sudanian
Western_Congolian
Dry_miombo
Angolan_wet
Guinean_forest-savanna
Zambezian_Baikiaea
Northern_Congolian
West_Sudanian
Zambezian-Limpopo_mixed
Kalahari_Acacia
Mandara_Plateau
Drakensberg_grasslands
Zambezian_mopane
Drakensberg_Escarpment
Angolan_mopane
Central_bushveld
Itigi-Sumbu_thicket
Campos_Rupestres
Sahelian_Acacia
Masai_xeric
Horn_of
Serengeti_volcanic
X-axis Label

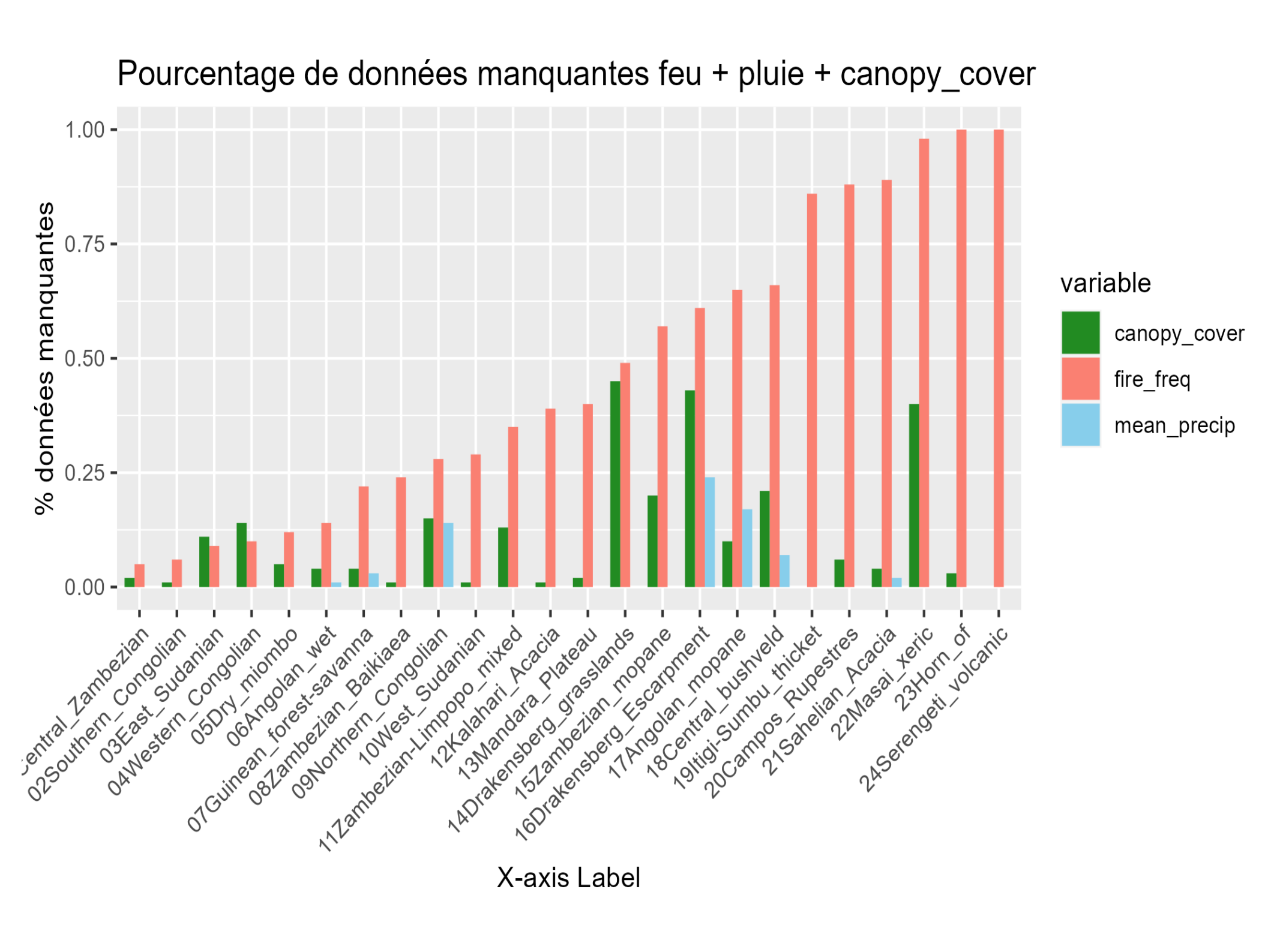

Pourcentage de données manquantes pluie moyenne annuelle
% données manquantes
1.00
0.75
0.50
0.25
0.00
ngolan_mopane
Angolan_wet
Campos_Rupestres
Central_bushveld
Central_Zambezian
Drakensberg_Escarpment
Drakensberg_grasslands
Dry_miombo
East_Sudanian
Guinean_forest-savanna
Horn_of
Itigi-Sumbu_thicket
Kalahari_Acacia
Mandara_Plateau
Masai_xeric
Northern_Congolian
Sahelian_Acacia
Serengeti_volcanic
Southern_Congolian
West_Sudanian
Western_Congolian
Zambezian-Limpopo_mixed
Zambezian_Baikiaea
Zambezian_mopane
X-axis Label

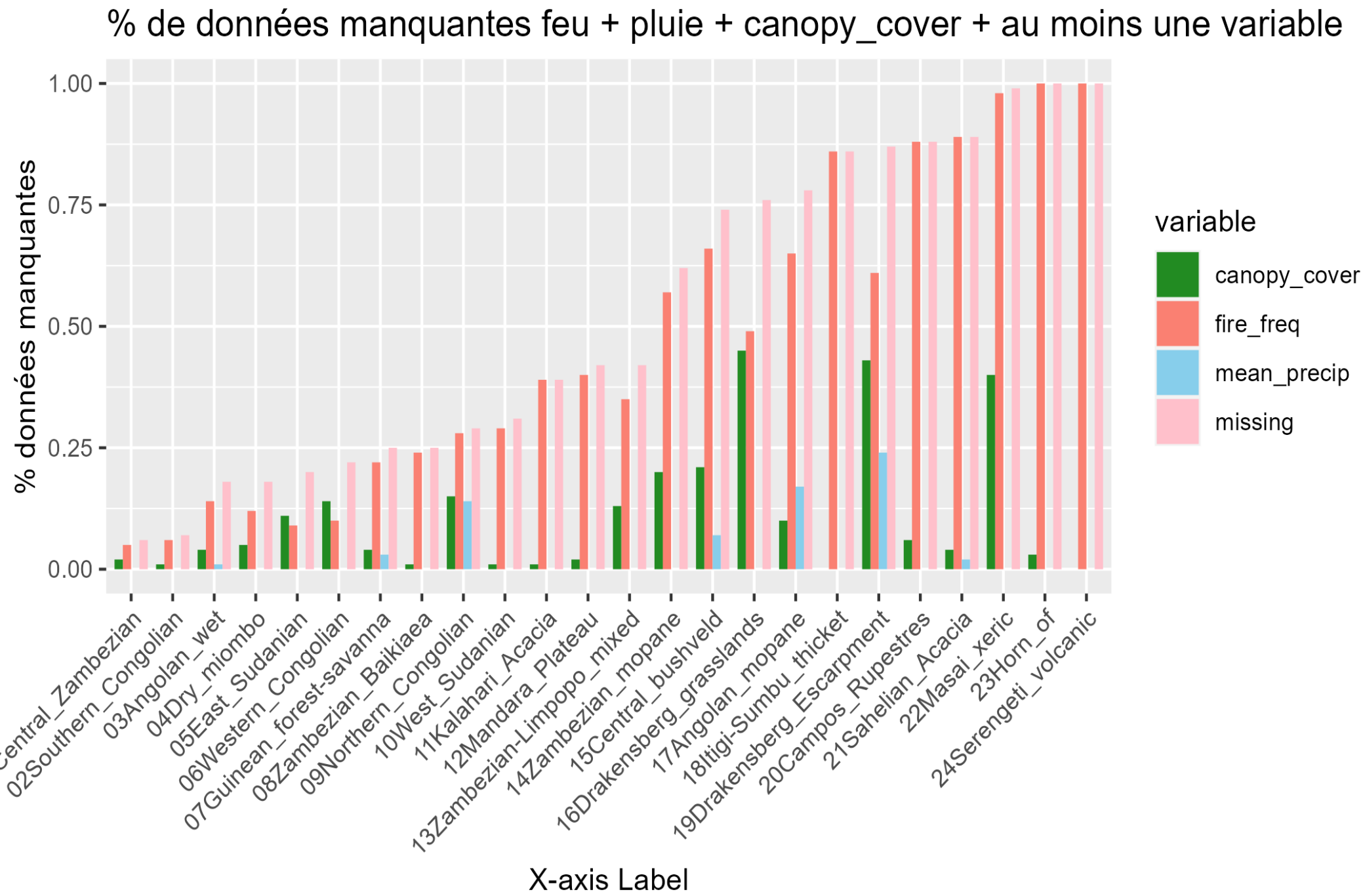

Pourcentage de données manquantes pluie moyenne annuelle
% données manquantes
1.00
0.75
0.50
0.25
0.00
Campos_Rupestres
Central_Zambezian
Drakensberg_grasslands
Dry_miombo
East_Sudanian
Horn_of
Itigi-Sumbu_thicket
Kalahari_Acacia
Mandara_Plateau
Masai_xeric
Serengeti_volcanic
Southern_Congolian
West_Sudanian
Western_Congolian
Zambezian-Limpopo_mixed
Zambezian_Baikiaea
Zambezian_mopane
Angolan_wet
Sahelian_Acacia
Guinean_forest-savanna
Central_bushveld
Northern_Congolian
Angolan_mopane
Drakensberg_Escarpment
X-axis Label

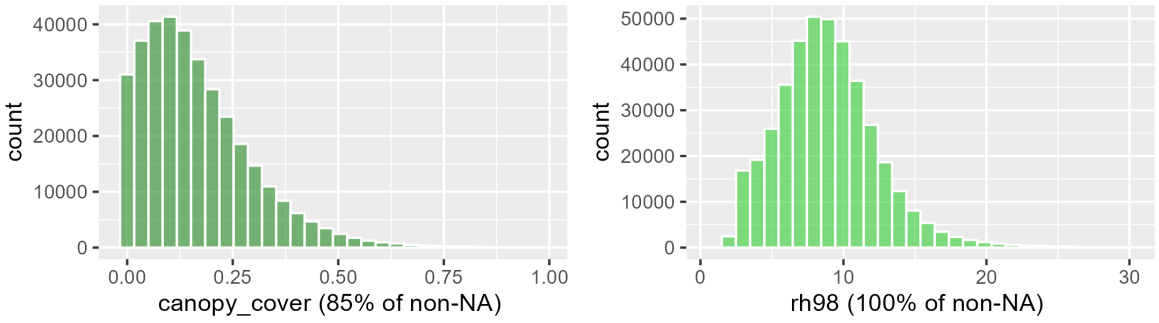

Pourcentage de données manquantes canopy_cover
% données manquantes
1.00
0.75
0.50
0.25
0.00
Angolan_mopane
Angolan_wet
Campos_Rupestres
Central_bushveld
Central_Zambezian
Drakensberg_Escarpment
Drakensberg_grasslands
Dry_miombo
East_Sudanian
Guinean_forest-savanna
Horn_of
Itigi-Sumbu_thicket
Kalahari_Acacia
Mandara_Plateau
Masai_xeric
Northern_Congolian
Sahelian_Acacia
Serengeti_volcanic
Southern_Congolian
West_Sudanian
Western_Congolian
Zambezian-Limpopo_mixed
Zambezian_Baikiaea
Zambezian_mopane
X-axis Label


Pourcentage de données manquantes canopy_cover
% données manquantes
1.00
0.75
0.50
0.25
0.00
Itigi-Sumbu_thicket
Serengeti_volcanic
Kalahari_Acacia
Southern_Congolian
West_Sudanian
Zambezian_Baikiaea
Central_Zambezian
Mandara_Plateau
Horn_of
Angolan_wet
Guinean_forest-savanna
Sahelian_Acacia
Dry_miombo
Campos_Rupestres
Angolan_mopane
East_Sudanian
Zambezian-Limpopo_mixed
Western_Congolian
Northern_Congolian
Zambezian_mopane
Central_bushveld
Masai_xeric
Drakensberg_Escarpment
Drakensberg_grasslands
X-axis Label

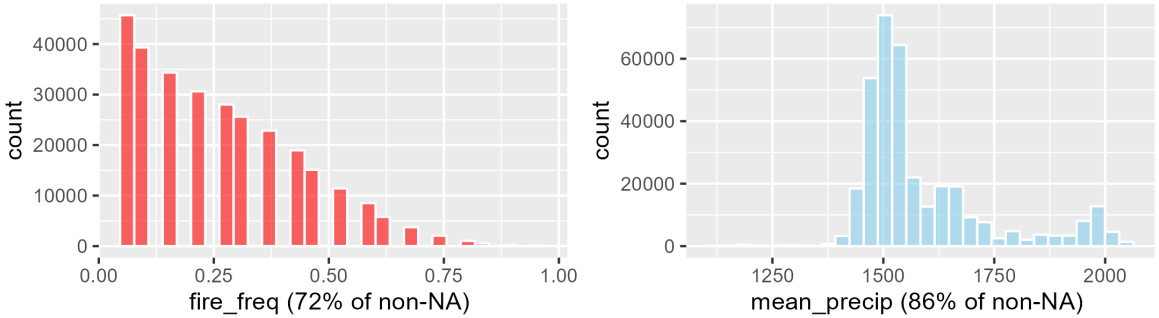

Pourcentage de données manquantes feu + pluie + canopy_cover
% données manquantes
1.00
0.75
0.50
0.25
0.00
Angolan_mopane
Angolan_wet
Campos_Rupestres
Central_bushveld
Central_Zambezian
Drakensberg_Escarpment
Drakensberg_grasslands
Dry_miombo
East_Sudanian
Guinean_forest-savanna
Horn_of
Itigi-Sumbu_thicket
Kalahari_Acacia
Mandara_Plateau
Masai_xeric
Northern_Congolian
Sahelian_Acacia
Serengeti_volcanic
Southern_Congolian
West_Sudanian
Western_Congolian
Zambezian-Limpopo_mixed
Zambezian_Baikiaea
Zambezian_mopane
X-axis Label
variable
canopy_cover
fire_freq
mean_precip


Pourcentage de données manquantes feu + pluie + canopy_cover
% données manquantes
1.00
0.75
0.50
0.25
0.00
variable
canopy_cover
fire_freq
mean_precip
Central_Zambezian
02Southern_Congolian
03East_Sudanian
04Western_Congolian
05Dry_miombo
06Angolan_wet
07Guinean_forest-savanna
08Zambezian_Baikiaea
09Northern_Congolian
10West_Sudanian
11Zambezian-Limpopo_mixed
12Kalahari_Acacia
13Mandara_Plateau
14Drakensberg_grasslands
15Zambezian_mopane
16Drakensberg_Escarpment
17Angolan_mopane
18Central_bushveld
19Itigi-Sumbu_thicket
20Campos_Rupestres
21Sahelian_Acacia
22Masai_xeric
23Horn_of
24Serengeti_volcanic
X-axis Label

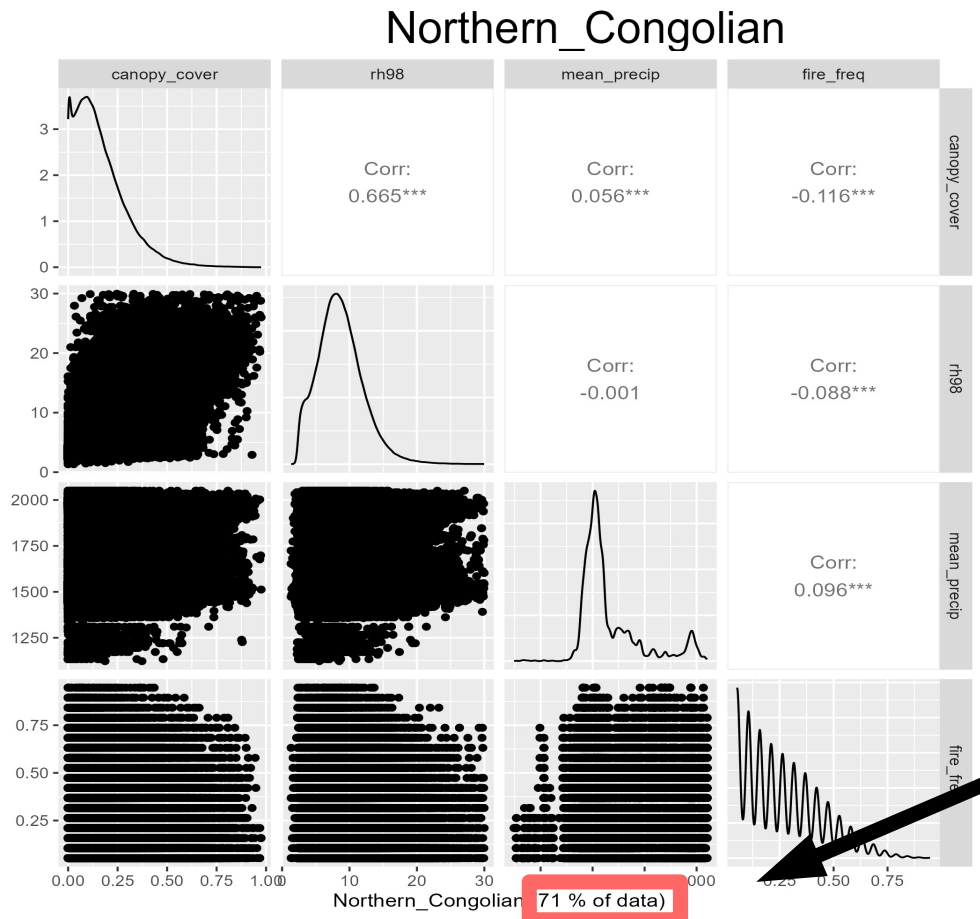

% de données manquantes feu + pluie + canopy_cover + au moins une variable
% données manquantes
1.00
0.75
0.50
0.25
0.00
variable
canopy_cover
fire_freq
mean_precip
missing
Central_Zambezian
02Southern_Congolian
03Angolan_wet
04Dry_miombo
05East_Sudanian
06Western_Congolian
07Guinean_forest-savanna
08Zambezian_Baikiaea
09Northern_Congolian
10West_Sudanian
11Kalahari_Acacia
12Mandara_Plateau
13Zambezian-Limpopo_mixed
14Zambezian_mopane
15Central_bushveld
16Drakensberg_grasslands
17Angolan_mopane
18Itigi-Sumbu_thicket
19Drakensberg_Escarpment
20Campos_Rupestres
21Sahelian_Acacia
22Masai_xeric
23Horn_of
24Serengeti_volcanic
X-axis Label

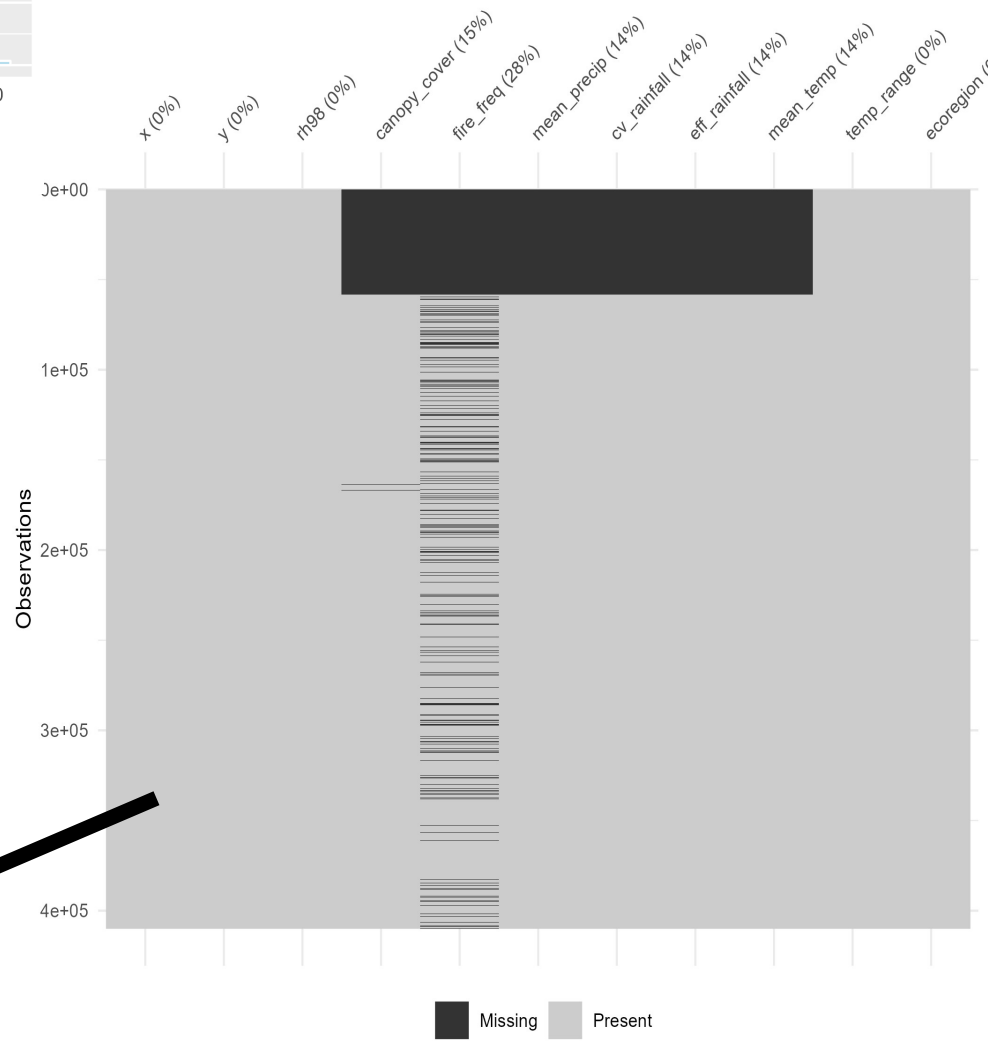

count
canopy_cover (85% of non-NA)

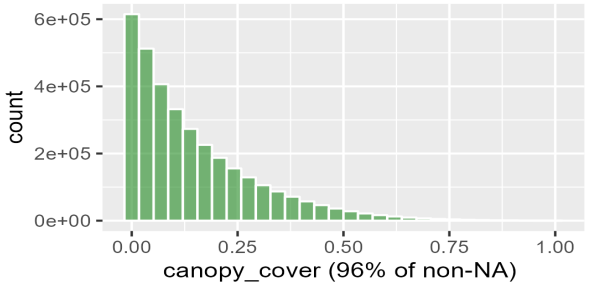
count
rh98 (100% of non-NA)

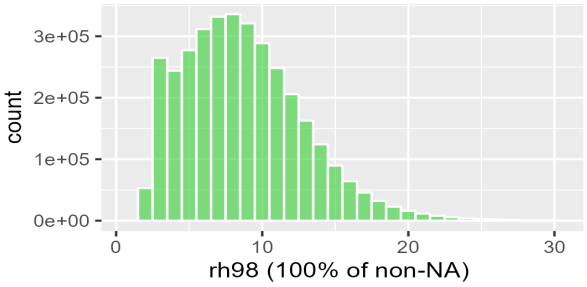

count
fire_freq (72% of non-NA)

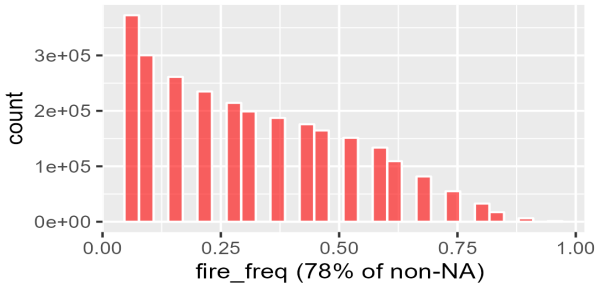
count
mean_precip (86% of non-NA)

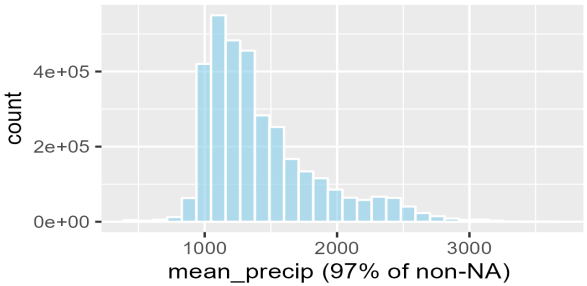

Northern_Congolian
canopy_cover
rh98
mean_precip
fire_freq
Corr:
0.665***
Corr:
0.056***
Corr:
-0.116***
Corr:
-0.001
Corr:
-0.088***
Corr:
0.096***
Northern_Congolian (71 % of data)

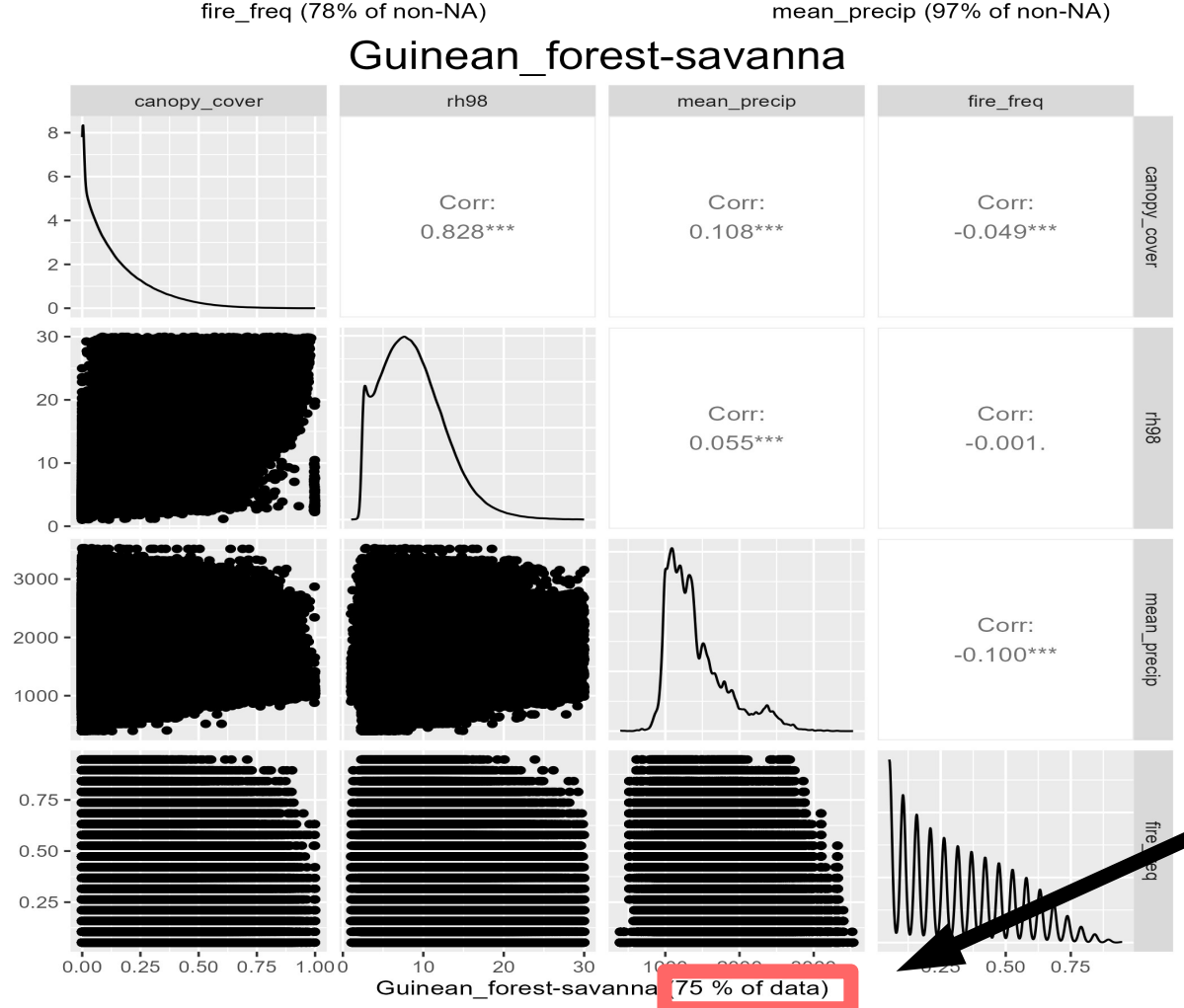

x (0%)
y (0%)
rh98 (0%)
canopy_cover (15%)
fire_freq (28%)
mean_precip (14%)
cv_rainfall (14%)
eff_rainfall (14%)
mean_temp (14%)
temp_range (0%)
Observations
Missing
Present

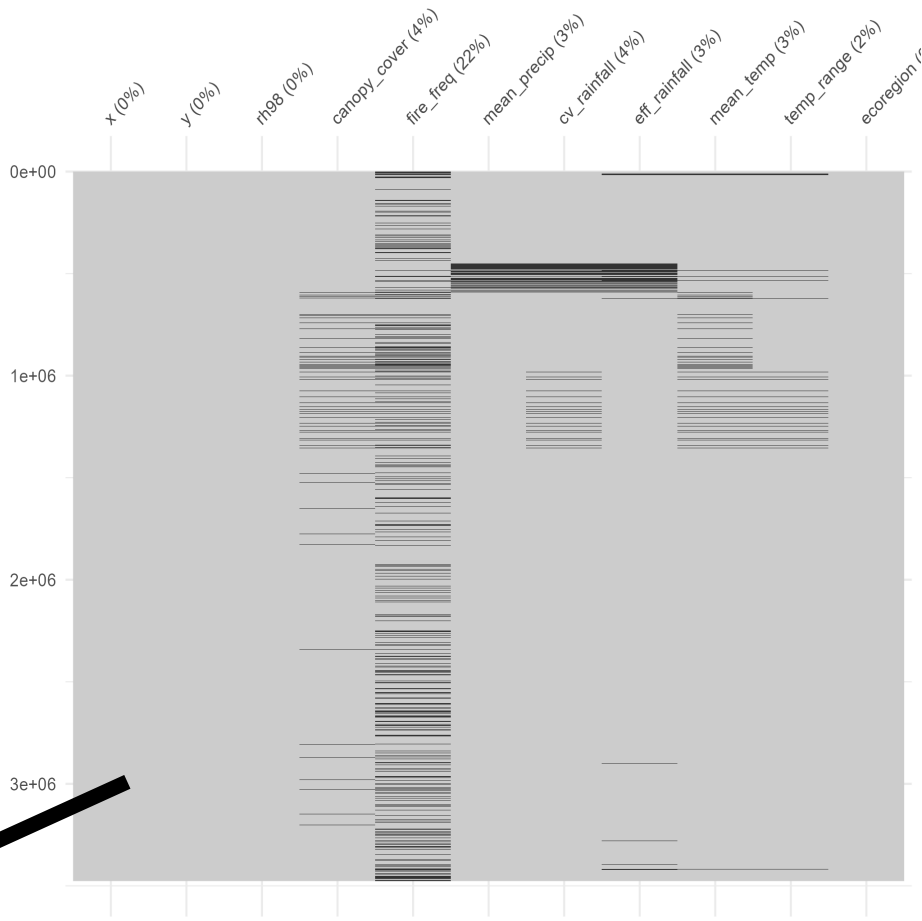

count
6e+05
4e+05
2e+05
0e+00
0.00
0.25
0.50
0.75
1.00
canopy_cover (96% of non-NA)

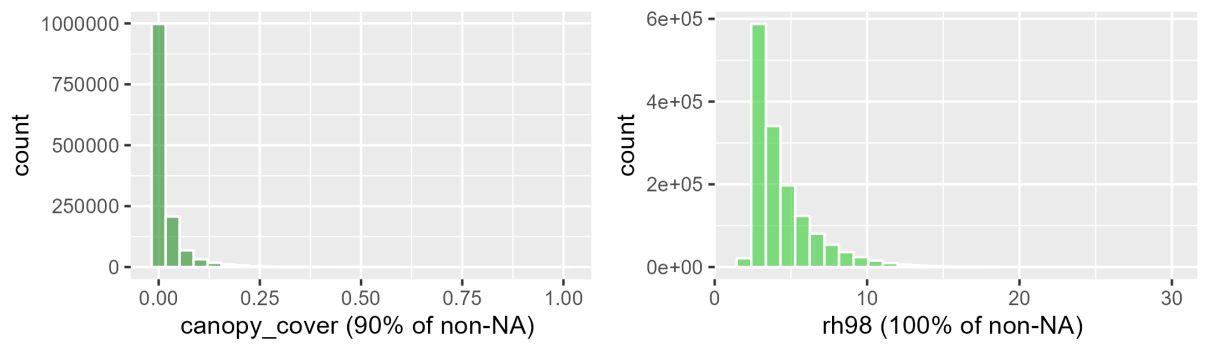

count
3e+05
2e+05
1e+05
0e+00
0
10
20
30
rh98 (100% of non-NA)


count
3e+05
2e+05
1e+05
0e+00
0.00
0.25
0.50
0.75
1.00
fire_freq (78% of non-NA)

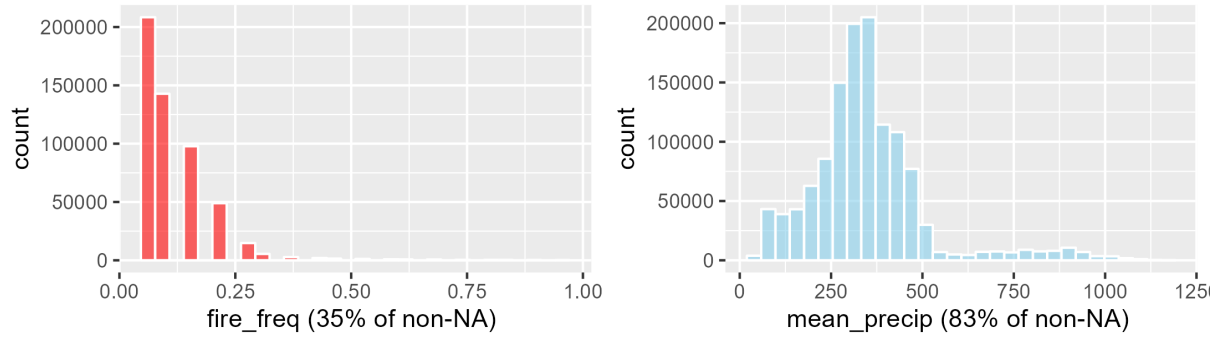

count
4e+05
2e+05
0e+00
1000
2000
3000
mean_precip (97% of non-NA)


Guinean_forest-savanna
canopy_cover
rh98
mean_precip
fire_freq
Corr:
0.828***
Corr:
0.108***
Corr:
-0.049***
Corr:
0.055***
Corr:
-0.001.
Corr:
-0.100***
canopy_cover
rh98
mean_precip
fire_freq
Guinean_forest-savanna (75 % of data)

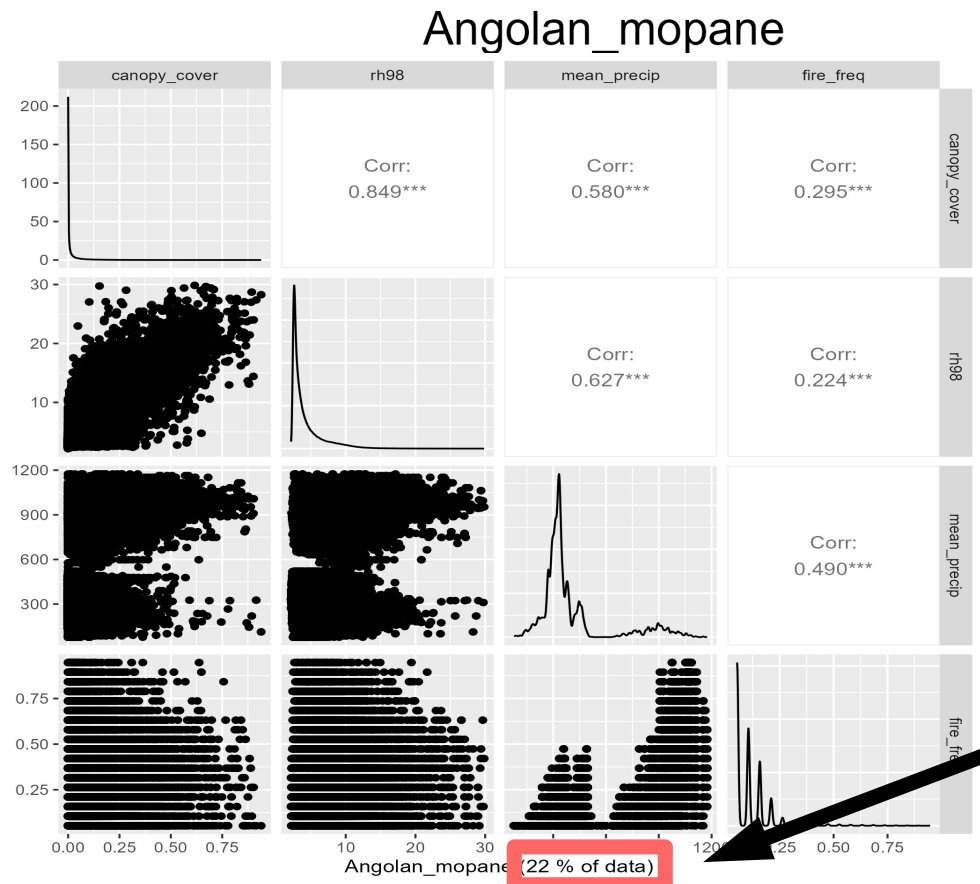

x (0%)
y (0%)
rh98 (0%)
canopy_cover (4%)
fire_freq (22%)
mean_precip (3%)
cv_rainfall (4%)
eff_rainfall (3%)
mean_temp (3%)
temp_range (2%)
0e+00
1e+06
2e+06
3e+06
Missing
Present

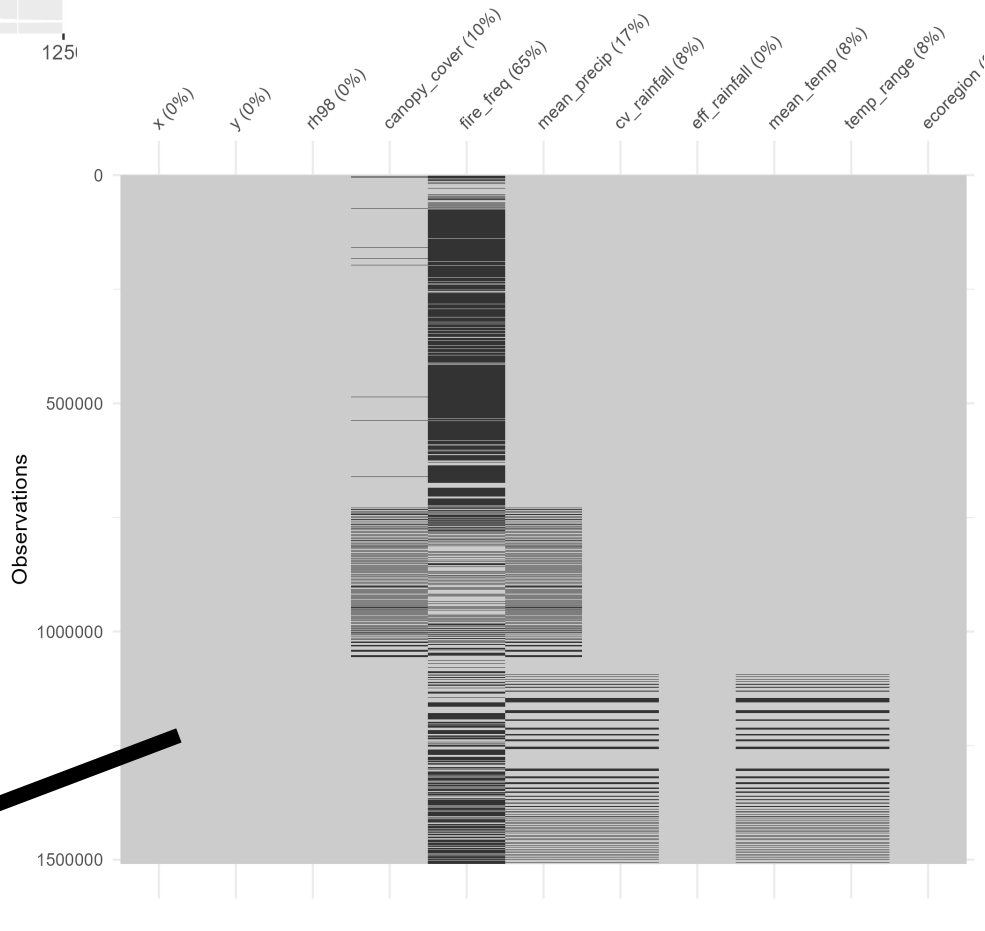

count
canopy_cover (90% of non-NA)

count
rh98 (100% of non-NA)


count
fire_freq (35% of non-NA)

count
mean_precip (83% of non-NA)


Angolan_mopane
canopy_cover
rh98
mean_precip
fire_freq
Corr: 0.849***
Corr: 0.580***
Corr: 0.295***
Corr: 0.627***
Corr: 0.224***
Corr: 0.490***
Angolan_mopane (22 % of data)


x (0%)
y (0%)
rh98 (0%)
canopy_cover (10%)
fire_freq (65%)
mean_precip (17%)
cv_rainfall (8%)
eff_rainfall (0%)
mean_temp (8%)
temp_range (8%)
Observations
Missing
Present

Salut Dominique et Aurelien,

J'ai essayé de fournir ci-dessous une description des variables générées. J'ai également rajouté des liens avec plus de détails sur l
peu de biblio à la fin pour se familiariser avec ces questions de dynamiques de transition forêt savane.

N'hésite pas si tu as des questions.

A+

Le Bien.

Environnemental variables:

1- fire_freq = 250-m yearly fire frequency (Fire/year) from MODIS Fire_cci Burned Area Pixel Product from 2001-2020. Each value
that pixel. Maxed pixel values from MODIS will have NA meaning there were no fire data for that given pixel.
2- mean_precip = Mean annual precipitation (MAP, mm/year) from ERA5 Monthly Aggregates (~ 30km resolution)
3- cv_rainfall = MAP variance (MAP, mm/year)
4- eff_rainfall = Effective rainfall (mm/year) is equal to the difference between MAP and the evapotranspiration.
5- mean_temp = Mean temperature (¤C)
6- temp_range = Temperature range (¤C)
7- ecoregion = The RESOLVE Ecoregions dataset from the WWF, updated in 2017. We focused on Tropical & Subtropical Grasslar
by MODIS canopy cover product).

Vegetation structure variables (see more details about GEDI here https://gedi.umd.edu/mission/technology/):
1- GEDI RH98 = canopy height measured from best quality filtered shots (25 m resolution) over savanna. We only considered pix
sure that we only consider data from woodlands and savanna.
2- GEDI canopy cover = proportion of the canopy between 5-10 m from the ground for each 25 m GEDI shot. This was extracted
https://developers.google.com/earth-engine/datasets/catalog/LARSE_GEDI_GEDI02_B_002_MONTHLY#description)

The GEDI data were aggregated from 25 m to 250 m resolution using the average values in order to match the resolution of the fi

https://doi.org/10.1002/fee.2585

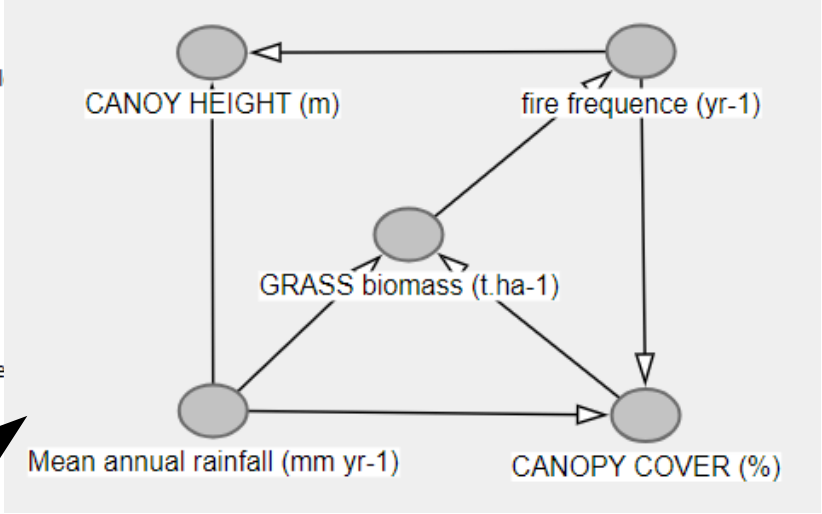
Sankaran, M., Hanan, N., Scholes, R. et al. Determinants of woody cover in African savannas. Nature 438, 846–849 (2005). https://d

Lehmann, C.E.R., Archibald, S.A., Hoffmann, W.A. and Bond, W.J. (2011), Deciphering the distribution of the savanna biome. New P

Marina Hirota et al. ,Global Resilience of Tropical Forest and Savanna to Critical Transitions. Science334,232-235(2011). DOI:10.112

Caroline E. R. Lehmann et al. ,Savanna Vegetation-Fire-Climate Relationships Differ Among Continents. Science 343, 548-552 (201

Higgins, S. I., Conradi, T., Kruger, L. M., O'Hara, R. B., & Slingsby, J. A. (2023). Limited climatic space for alternative ecosystem state



Testable implications

The model implies the following conditional independences:

- CANOPY COVER (%) ⊥ CANOY HEIGHT (m) | Mean annual rainfall (mm yr-1), fire frequence (yr-1)
- CANOY HEIGHT (m) ⊥ GRASS biomass (t.ha-1) | Mean annual rainfall (mm yr-1), fire frequence (yr-1)

Model code

```
dag {
bb="0,0,1,1"
"CANOPY COVER (%)"
[pos="0.528,0.613"]
"CANOY HEIGHT (m)"
[pos="0.173,0.300"]
"GRASS biomass (t.ha-1)"
[pos="0.334,0.457"]
"Mean annual rainfall (mm yr-
1)" [pos="0.174,0.609"]
```

Summary

Model contains cycle: CANOPY COVER (%)→GRASS biomass (t.ha-1)→fire frequence (yr-1)→CANOPY COVER (%)