

## **Inter-annual variation of species composition in semi-arid environments - implications for vegetation studies**

Alexander Wezel<sup>1</sup> and Eva Schlecht<sup>2</sup>

<sup>1</sup>Institute for Landscape Ecology, Nature Conservation and Botany, University of Greifswald, Grimmer Straße 88, 17487 Greifswald, Tel.: 03834/ 864185, Fax: 03834/864187

Email: [wezel@mail.uni-greifswald.de](mailto:wezel@mail.uni-greifswald.de)

<sup>2</sup>Institute for Animal Production in the Tropics and Subtropics, University of Hohenheim/Stuttgart; c/o ICRISAT, B.P. 12404 Niamey, Niger, Email: [E.Schlecht@cgiar.org](mailto:E.Schlecht@cgiar.org)

### **Abstract**

To monitor inter-annual changes of species composition, permanent plots were investigated on three different fallow sites in Niger, West Africa from 1994 to 1998. The number of different species observed per plot varied between the years, with some species being absent in one year but present in the next. Likewise, the frequency of occurrence of individual species varied between years. On all sites, certain species occurred in all years, but their abundance changed enormously from year to year. Species abundant in some years but absent in others are not useful to function as character species for the distinction of plant communities. Therefore it would be of advantage to identify a group of species with similar fluctuation trends for specific precipitation patterns and site conditions, so that some of them are present on the site each year.

*Keywords: herbaceous fallow vegetation, rainfall variability, West Africa*

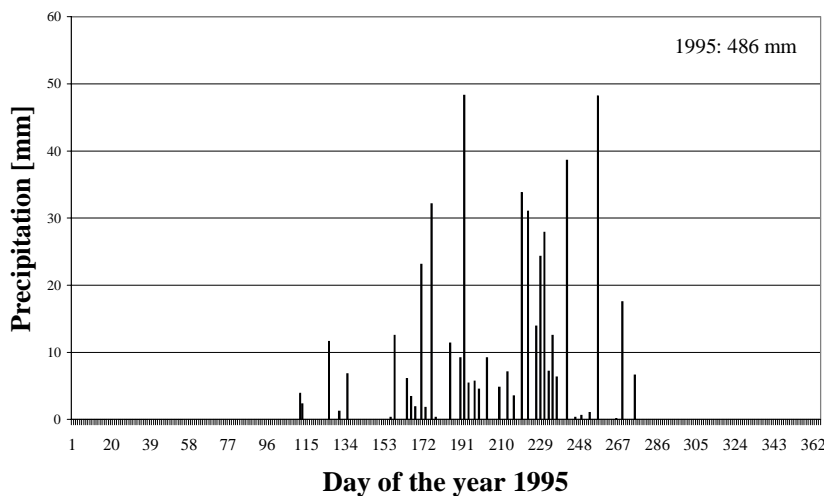
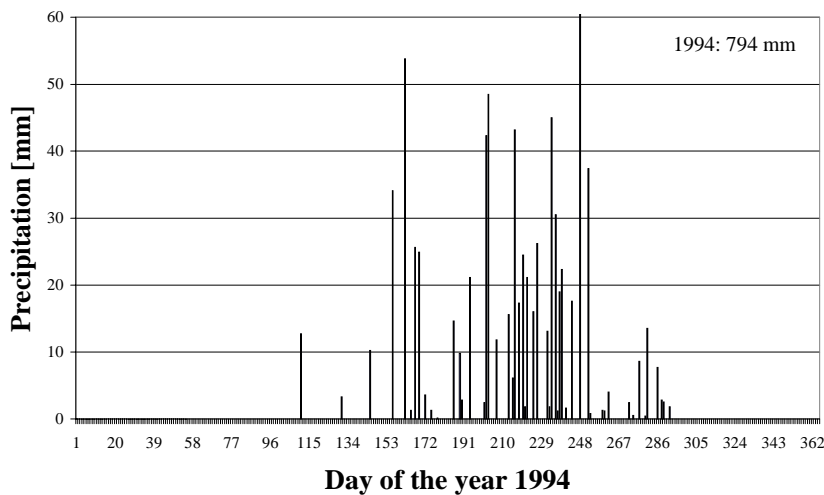
### **Introduction**

The climate of semi-arid environments is characterised by long drought periods and few months of rainfall. A high inter-annual and intra-annual variability of the precipitation is typical. For studies of the herbaceous vegetation this is of decisive importance because species composition, especially that of annual plant communities, is often determined by the amount and distribution of the first rains as well as the total amount of rainfall (see also Elberse and Breman, 1990, Poissonet et al., 1992, Seghieri et al., 1994). Species which seem to be useful as character species for plant communities or as indicator species for different objectives may be present in one year but absent in the following year.

To monitor this, permanent observation plots were established on three different fallow sites in south-west Niger.

### Material and methods

Herbaceous fallow vegetation of three permanent plots was surveyed from 1994 to 1998 in Niger, West Africa using the Braun-Blanquet method for estimation of species abundance and dominance (Braun-Blanquet, 1964). Plots (40-50 m<sup>2</sup>) were monitored each year at the end of September to beginning of October. The scientific names follow Hutchinson et al. (1954, 1972). The description of the fallow plant communities and their site characteristics is presented in Wezel and Boecker (1998).



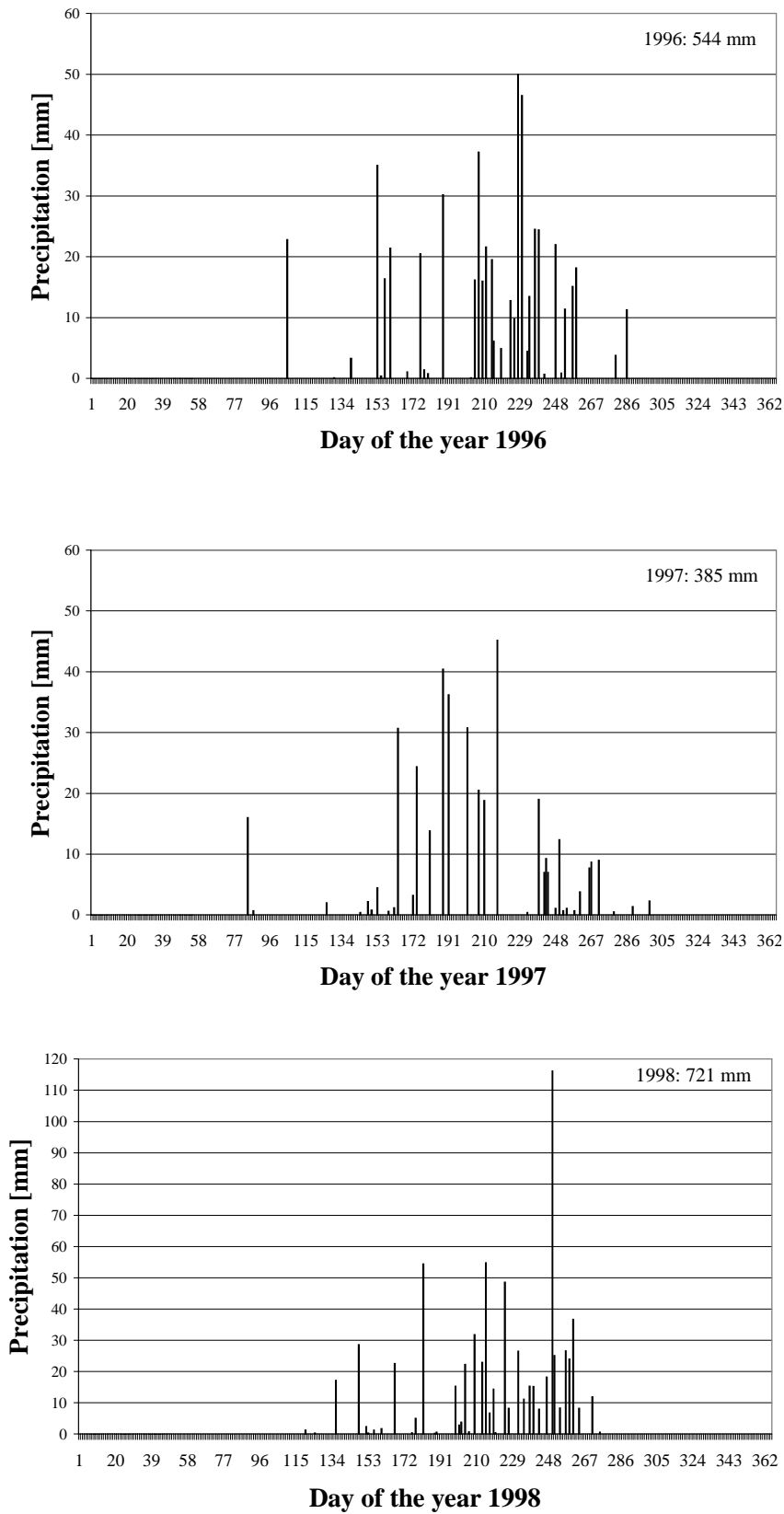


Figure 1-5: Precipitation at ICRISAT Sahelian Center, Niger, in the years 1994-1998

Two of the permanent plots, a protected fallow and grazed fallow site, were located on deep sandy soils (luvic Arenosol). The third site, which was grazed, was situated on a shallow soil (dystric Leptosol). Both soil types are characterised by a low pH and low organic matter and nitrogen content. All sites were located at the ICRISAT Sahelian Center, situated 45 km south-east of Niger's capital Niamey. The climate at this location is semi-arid with a rainy season from June to September and a mean annual precipitation of 550 mm (Fig. 1-5).

## Results and Discussion

Changes of species abundance and frequency as well as absence in some of the years analysed could be found. For each site, one group of species was identified which occurred in all years, but which could also change enormously in abundance from year to year (Species group 1, Tab. 1-3).

Species of the second group, mostly Poaceae (Tab. 1 and 2), were even absent in 1998. In this year, almost all grasses died after germination because they were buried by sand from heavy storms, or when germinating again, were eaten by small grasshoppers. This was also observed for the third group of species on the grazed sandy site (Tab. 2).

Further comparison of abundance and dominance of species present at all three sites shows significant changes for a range of species.

*Merremia pinnata* changed enormously in dominance from year to year (Tab. 1 and 3), or even disappeared (Tab. 2). Similar changes were recognised for *Borreria stachydea*, *Zornia glochidiata* and *Alysicarpus ovalifolius*.

Tab. 1: Species occurrence on the protected fallow site located on deep sandy soil

Year	1995	1996	1997	1998
Cover of herb layer [%]	65	40	85	95
Age of fallow [a]	17	18	19	20
<b>Species group 1</b>				
<i>Merremia pinnata</i>	3	2b	2b	5
<i>Indigofera strobilifera</i>	2a	2a	2m	1
<i>Indigofera pilosa</i>	1	2a	1	1
<i>Alysicarpus ovalifolius</i>	x	x	1	1
<i>Cassia mimosoides</i>	x	1	1	1
<i>Zornia glochidiata</i>	x	x	2m	2m
<i>Polycarpaea linearifolia</i>	1	1	2a	x
<i>Ceratoteca sesamoides</i>	1	x	x	r
<b>Species group 2</b>				
<i>Diheteropogon hagerupii</i>	1	1	2a	.
<i>Ctenium elegans</i>	2m	2m	2m	.
<i>Digitaria gayana</i>	2m	x	r	.
<i>Schizachirium exile</i>	x	r	r	.
<i>Borreria radiata</i>	1	1	2m	.
<i>Tephrosia linearis</i>	1	2a	2m	.
<i>Borreria stachydea</i>	.	x	x	r
<i>Blepharis linariifolia</i>	.	x	2m	x
<i>Hibiscus asper</i>	x	r	.	1
<i>Striga gesnerioides</i>	x	r	.	.
<i>Eragrostis tremula</i>	x	.	r	.
<i>Pandiaka heudelotii</i>	.	.	1	x

Other species occurring only once:

*Brachiaria distichophylla* 94/x, *Fimbristylis hispidula* 97/2m, *Commelina forskalaei* 97/1, *Microchloa indica* 97/r, *Polycarpaea eriantha* 97/1, *Indigofera priureana* 98/x, *Jacquemontia tamnifolia* 98/1.

r:	1 individual	2b:	cover 16-25%
+	2-5 individuals, cover < 5%	3:	cover 26-50%
1:	6-50 individuals, cover < 5%	4:	cover 51-75%
2m:	> 50 individuals, cover < 5%	5:	cover 76-100%
2a:	cover 5-15%		

On sites with compacted soil horizons, growing conditions for herbaceous plants are limited due to water shortage in the upper horizon, occurring even in the rainy season. Here, specifically adapted species such as *Loudetia togoensis* dominate (Tab. 3). In general, the abundance and dominance of species occurring under these particular soil conditions is more constant and less dependent on the rainfall variability than the occurrence of species on the deep sandy soils.

Tab. 2: Species occurrence on the grazed fallow site located on deep sandy soil

Year	1994	1995	1996	1997	1998
Cover of shrub layer [%]	5	5	3	1	1
Cover of herb layer [%]	50	40	45	25	75
Age of fallow [a]	16	17	18	19	20
<b>Species group 1</b>					
Zornia glochidiata	3	3	3	2b	4
Cassia mimosoides	1	+	1	1	2m
Guiera senegalensis	2a	2a	1	r	r
Alysicarpus ovalifolius	1	+	1	+	r
Commelina forskalaei	+	1	1	1	+
Waltheria indica	+	1	+	1	r
<b>Species group 2</b>					
Ctenium elegans	r	+	1	1	.
Digitaria gayana	1	1	1	r	.
Aristida adscensionis	+	+	+	1	.
Digitaria horizontalis	+	+	1	1	.
Borreria radiata	1	1	1	+	.
Merremia pinnata	1	r	+	r	.
<b>Species group 3</b>					
Dactyloctenium aegypticum	.	1	+	1	.
Eragrostis tremula	.	+	+	1	.
Brachiaria xantholeuca	.	+	r	1	.
Sida cordifolia	.	1	1	+	2m
Mitracarpus scaber	+	+	r	.	r
Blepharis linearifolia	+	r	.	r	r
Cerathoteca sesamoides	1	1	.	r	r
Borreria stachydea	+	1	r	.	.
Ipomoea vagans	2a	1	+	.	.
Monechma ciliatum	+	+	r	.	.
Polycarpaea linearifolia	+	+	.	.	.
Triumfetta pentandra	+	+	.	.	.
Cenchrus biflorus	+	+	.	.	.
Fimbristylis hispidula	.	+	.	1	.
Crotalaria atrorubens	1	.	+	.	.

Other species occurring only once:

Jacquemontia tamnifolia 94/r, Tephrosia linearis 94/r, Cyperus amabilis 94/+, Sporobolus paniculatus 95/+, Indigofera pilosa 96/+, Phyllanthus pentandrus 96/+, Indigofera strobilifera 96/r, Schoenefeldia gracilis 97/+, Striga gesnerioides 97/r, Aristida mutabilis 97/1, Pandiaka heudelotii 97/r, Microchloa indica 97/1, Eragrostis pilosa 97/+.

Tab. 3: Species occurrence on the grazed fallow site located on shallow soil

Year	1994	1995	1996	1997
Cover of herb layer [%]	50	70	50	40
Age of fallow [a]	12	13	14	15
<b>Species group 1</b>				
<i>Loudetia togoensis</i>	3	3	3	4
<i>Merremia pinnata</i>	2a	1	2a	2m
<i>Indigofera strobilifera</i>	2a	2a	2a	2m
<i>Borreria radiata</i>	1	1	2a	2m
<i>Cassia mimosoides</i>	2a	+	1	1
<i>Borreria stachydea</i>	+	+	1	r
<i>Fimbristylis hispidula</i>	1	1	1	1
<i>Eragrostis tremula</i>	1	1	+	1
<i>Cerathoteca sesamoides</i>	1	1	+	1
<i>Phyllanthus pentandrus</i>	1	+	+	1
<i>Polycarpha linearifolia</i>	1	+	+	1
<i>Alysicarpus ovalifolius</i>	.	r	+	r
<i>Digitaria gayana</i>	.	1	1	1
<i>Indigofera pilosa</i>	.	+	+	r
<i>Ctenium elegans</i>	1	1	2m	.
<i>Tephrosia linearis</i>	1	1	+	.
<i>Ipomoea vagans</i>	+	r	r	.
<i>Zornia glochidiata</i>	.	.	+	+
<i>Waltheria indica</i>	.	r	.	+
<i>Andropogon gayanus</i>	r	.	r	.
<i>Indigofera congolensis</i>	.	+	1	.

Other species occurring only once:

*Citrullus colocynth* 95/+, *Schizachyrium exile* 95/r, *Borreria filifolia* 96/r, *Striga gesnerioides* 96/r, *Sida cordifolia* 96/+, *Piliostigma reticulatum* herb 96/r, *Hibiscus asper* 96/r, *Digitaria horizontalis* 97/+, *Polycarpha eriantha* 97/1, *Tephrosia lupinifolia* 97/1.

Of course, grazing has a certain impact on species composition. The number of species that occurred only in one of the surveyed years was lowest in the protected fallow (7 species) and highest on the grazed, sandy site (15 species). An intermediary site is the fallow with the shallow soil (10 species).

In relation to soil texture, similar trends can be recognised for the number of species changing in presence and absence. On sandy soils, the number of these species was higher compared to shallow soils or to sites in depressions (see also Wezel 1998).

## Conclusions

The presented inter-annual fluctuation of abundance and / or frequency of various species signifies a considerable problem for vegetation studies. For phyto-sociological approaches, and also for indicator species analysis, many species which are abundant in some years, but absent in others, are not useful to function as character or differential species for the distinction of plant communities. Still, these species can be of a certain value. If species fluctuations are known from permanent plot analysis, they can be used to indicate certain site characteristics in years of presence. But it would be more preferable to identify a whole group of species with similar fluctuation trends for specific precipitation patterns and site conditions, so that at least some of them are present on the site each year (see also Wezel 1998).

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