The effect of cutting on the floodplain vegetation of Amani, Tanzania.

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Abstract

The plant community of the floodplain above Amani pond was studied between 15 and 21 September 2003. Various community aspects, principally diversity and richness, were compared between paired cut and uncut quadrants. Family diversity was found to be significantly higher at uncut than cut sites, whilst richness was higher in cut sites. In contrast, species diversity and richness were affected only by distance along the floodplain (presumably due to an unmeasured environmental variable). Similarity between cut and uncut quadrants was low (0.32 with Sorenson's index), which indicates significantly different species composition between cut and uncut sites. This has important implications for the conservation of maximum biodiversity in Amani Nature Reserve: although cutting is illegal, its removal could result in lower plant diversity at Amani floodplain.

Introduction

The diversity of species is often associated with the heterogeneity of a habitat. This is because as habitat complexity increases, the amount of available niches increases. After the establishment of a particular ecosystem, the habitat may become more and more uniform, leading to the dominance of only a few species in a 'climax community' (Huston, 1994). Moderate disturbance can be a good way to increase the plant species diversity.

Grasslands are a good example of an ecosystem that can be very dependent upon an appropriate level of disturbance, such as fire or herbivore grazing. When this does not occur, it very often leads to a 'take over' of woody species (Huston, 1994). There is an important difference between biotic and abiotic disturbances (Begon et al, 1990). The first type is often very selective, for example, herbivores may be specialists and so prefer certain plants, allowing less palatable plants to flourish. In contrast, abiotic disturbances usually have more general influences, and may affect all members of a community (for example, a hurricane may flatten all plants). These different effects of biotic and abiotic disturbance may therefore be reflected by different changes in species composition.

We were interested to see if similar effects of disturbance could be seen in the tropical floodplain system of Amani. The adjacent Amani Nature Reserve has a zero grazing policy, so floodplain vegetation is cut by local people for cattle fodder, even though this is illegal. This creates a patchy pattern of cut and uncut habitats. In other systems similar human induced disturbances can lead to changes in vegetation composition, for example, cattle grazing in north-west Europe increases plant species richness (Bokdam & Gleichman, 2000). As Amani Nature Reserve lies within the Eastern Arc Mountains, which contain high levels of endemism and biodiversity (Iversen, 1991), comparable changes in its floodplain vegetation could have important implications for reserve management, which aims to maximise biodiversity conservation. We therefore decided to investigate plant community in cut and uncut floodplain microhabitats.

Aim

To compare the composition and diversity of species and families, between cut and uncut areas of floodplain vegetation.

Methods

Study area

The study was conducted along a floodplain associated with the Zigi River, just above Amani pond (5°06'S, 38°38'E). Neither the 'top' end of the floodplain, (furthest from Amani), nor the 'bottom' end (near Amani pond) were sampled. The Zigi runs through the Amani Nature Reserve in the East Usambara Mountains, Tanzania.

Identification

An initial survey of the floodplain was made to collect as many plant species as possible. These specimens were then identified to at least family level, or preferably genus or species level. Those species that we were not able to identify were assigned to morpho-species. After identification, representatives of all species found were collected in a herbarium.

Data collection

All data were collected over a period of seven days, between 15 September 2003 and 21 September 2003.

The study area was roughly mapped and the boundaries between cut versus uncut vegetation marked on the map (app. 1). On the map, all sampling sites containing a boundary between cut and uncut vegetation were labelled. Vegetation was defined as 'cut' if its maximum height was below 0.30m and the leaves of the vegetation had obviously been severed. Vegetation was judged to be uncut if no evidence of recent human impact was observed.

A total of 20 paired quadrants, of one metre by one metre (total 40 quadrants) were randomly selected from these labelled sites, so each pair consisted of one cut and one uncut quadrant. Sites judged to be very close to the stream were avoided to prevent recording vegetation differences due to stream effects on microhabitat. In each quadrant, the following parameters related to plant communities were recorded:

- Cut or uncut.
- Species presence.
- % Species estimated visual cover.
- % Tree cover (estimated within a one metre range of the quadrant to estimate the total shading effects from surrounding trees.)
- Vegetation height (the average height of the dominant vegetation, in centimetres).
- Palatability. This was recorded with a categorical six graded scheme similar to that recommended by Oudtshoorn (1992): 1 = none or very low; 2 = Low; 3 = Low to medium; 4 = Medium; 5 = Medium to high; 6 = High.

Abiotic data collection.

In alternate paired quadrants, working down through the floodplain, pH, redox and conductivity were measured using a water test meter (although both conductivity and pH readings were later discarded due to meter error). To measure soil humidity, a standardised amount of soil was collected and weighed before and after the evaporation of water (by oven). These data were collected over one day to control for climate effects. Distance down the floodplain, towards the pond, was estimated with the sketch map.

Data analysis

All data were analysed, where possible, with appropriate parametric tests. General Linear Model ANOVA analysis was used where residuals were normal, even if the raw data were not. Where data were not normal (even after transformation), appropriate non-parametric tests were used, as described by Siegel and Castellan (1988). The results of paired tests were illustrated by histograms of the differences between paired cut and uncut quadrants, for example the differences in diversity or richness. An $\propto$-level of 0.05 was used for all tests.

Family abundances were calculated by combining the abundances of all species within one family, for each quadrant. Diversity was calculated from relative species abundances with the Shannon-Weiner index (H′), which is calculated with the following formula: $H = Pi \times \ln Pi$. (Where Pi= proportionate species abundance).

Evenness (E) was calculated from Hill’s modified ratio (Waite, 2000), with the following formula: $E = \frac{N_2 - 1}{N_1 - 1}$. (N_1=1-D, where D=Simpson’s index and N_2=$\exp^{H'}$.)

Our similarity index (S) was calculated following Sorenson (Waite, 2000), with the following formula (where ‘a’= species co-occurring in both cut and uncut quadrants, ‘b’=species unique to cut quadrant and ‘c’= species unique to uncut quadrant.)

$$S = \frac{2a}{2a + b + c}$$ S ranges from 0 (no similarity) to 1 (maximum similarity).

Results

Family level analyses

There was higher family diversity in uncut than cut quadrants (Mann-Whitney U, $W=211.0$, $p<0.001$). In contrast, family richness was higher in uncut quadrants (paired t-test, $t=2.28$, $p=0.034$). Evenness did not differ between cut and uncut sites.

Family level diversity was also correlated with vegetation height (Pearson correlation, $P=0.832$, $p<0.001$; figure 3).

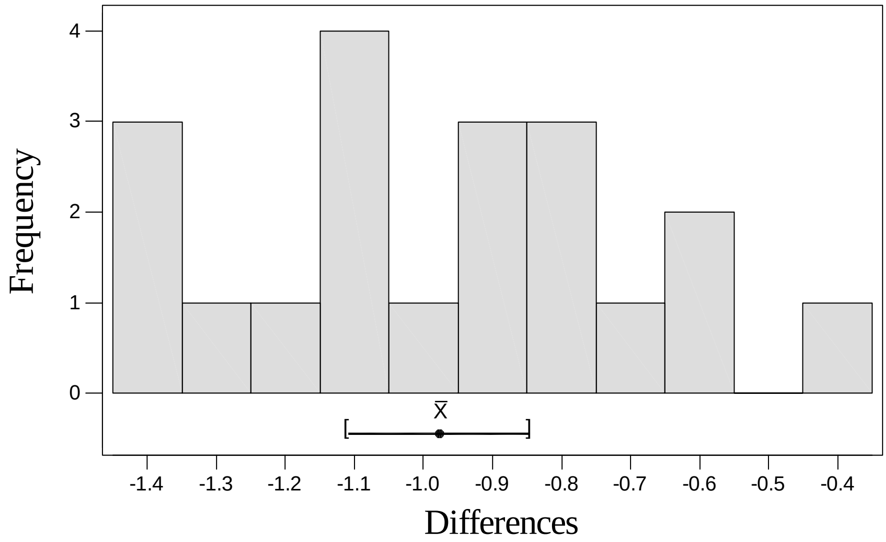

Figure 1. A comparison of family level diversity between cut and uncut sites (cut quadrant diversity minus uncut quadrant diversity). N=20. Shannon-Weiner index used to calculate diversity. All data collected from Amani floodplain, Tanzania.

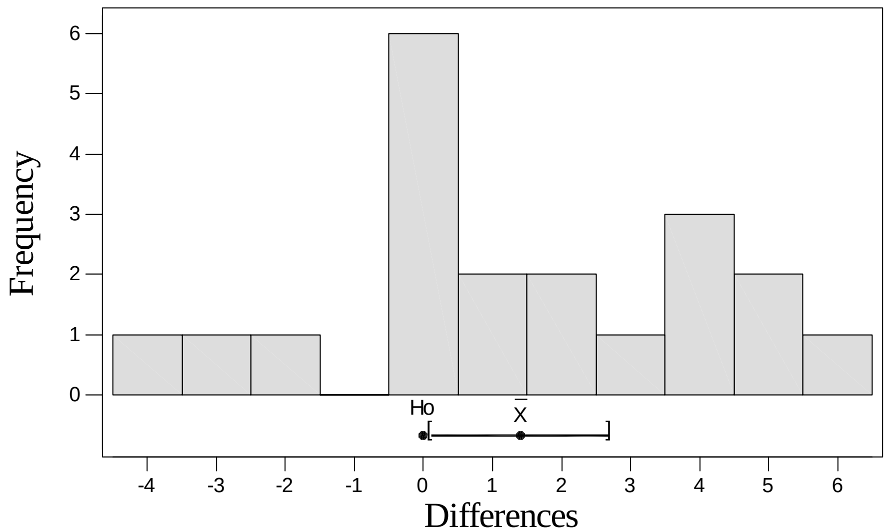

Figure 2. A comparison of family level richness between cut and uncut sites (cut quadrant richness minus uncut quadrant richness). N=20. All data collected from Amani floodplain, Tanzania.

Species level analysis

Species level diversity and richness trends were similar to those at the family level, but none were significant. Evenness also did not differ between cut and uncut sites. However, the mean similarity, using Sorenson's index (Waite, 2000) between cut and uncut quadrants was 0.325, indicating different species compositions. Multivariate analysis showed distance along the floodplain (towards the pond) to be a significant predictor of species diversity and species richness (GLM, $F_{1,39}$=2.86, p=0.013; $F_{1,39}$=2.29, p=0.038). Tables 1 and 2 illustrate this.

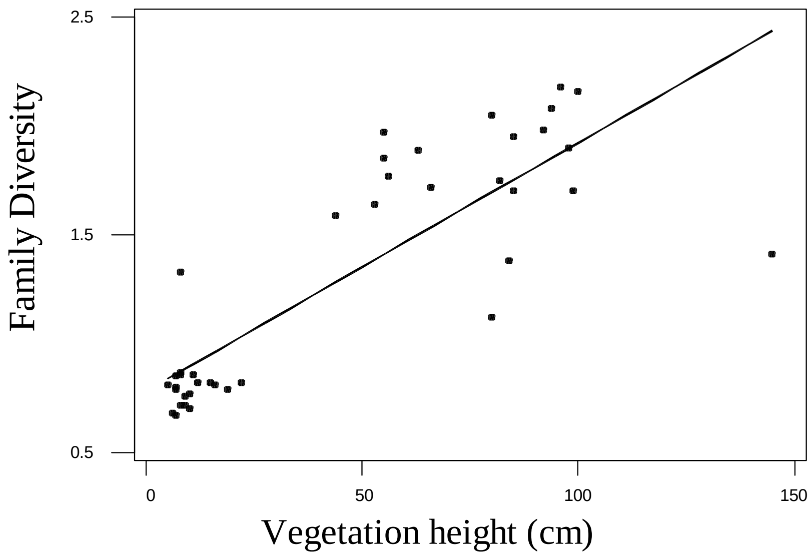

Figure 3. A correlation between vegetation height and family diversity; N=40. Diversity calculated using the Shannon-Weiner index for data collected from Amani floodplain, Tanzania.

Table 1. Shows the ANOVA table for a general linear model with cut/cut and distance along Amani floodplain as predictors of species diversity. Diversity calculated with Shannon-Weiner index.

Source	**DF**	**Seq. SS**	**Adj. SS**	**Adj. MS**	**F value**	**P Value**
Cut/uncut	1	0.04356	0.04356	0.04356	0.69	0.417
Distance	18	3.26171	3.26171	0.18121	2.86	0.013
Error	20	1.26704	1.26764	0.06335		
Sum	39	4.57231				

Table 2. Shows the ANOVA table for a general linear model with cut/uncut and distance along Amani floodplain as predictors of species richness

Source	**DF**	**Seq. SS**	**Adj. SS**	**Adj. MS**	**F value**	**P value**
Cut/uncut	1	0.012603	0.012603	0.012603	1.27	0.274

Distance	18	0.409548	0.409548	0.022753	2.29	0.038
Error	20	0.198948	0.198948	0.009947		
Sum	39	0.621098				

Controls and other variables

Tree cover and our other measured physical factors (redox and humidity) showed no significant difference between cut or uncut sites, and no correlations with our vegetation measurements or distance along the floodplain. As we expected, vegetation was significantly higher in uncut quadrants (mean difference of 70.4 cm), but vegetation also decreased in height with increasing distance towards to the pond (figure 4). Cut sites also contained significantly more palatable vegetation (Sign test, k=0, p<0.0005; figure 5).

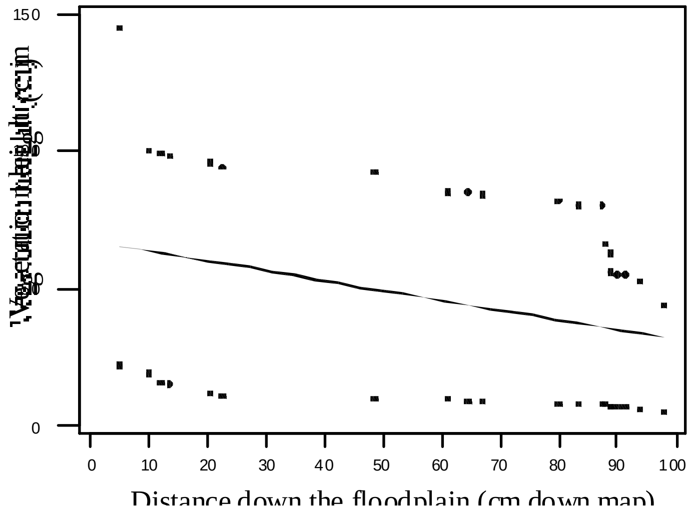

Figure 4. A correlation between distance down the floodplain, towards the pond (estimated from map) and vegetation height. N=40. All data collected from Amani floodplain, Tanzania.

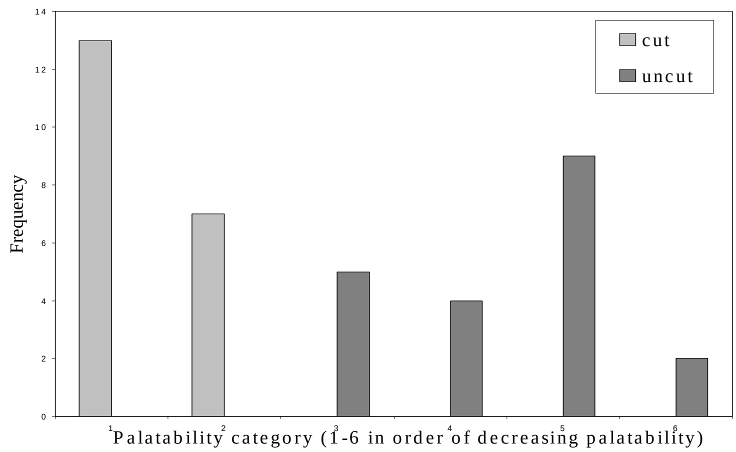

Figure 5. A graph to show how cut and uncut vegetation differs in palatability (6 graded categorical scale), on Amani floodplain, Tanzania. N=40.

Discussion

Our results show a high degree of family richness in areas where the vegetation has been cut, perhaps due to cutting creating opportunities for smaller specimens, pioneers and species adapted to cutting. This is predicted by the 'intermediate disturbance hypothesis' (Begon et al, 1990), which predicts a peak of diversity when there are intermediate levels of small-scale disturbance (Rosenzweig, 1985).

In contrast, family diversity is generally higher in uncut quadrants. This suggests that family abundances are more evenly distributed in uncut than cut quadrants, with less dominance, whilst cut areas have greater family representation, although some of them are rare. This concurs with Huston (1994), who suggests that disturbance (in this case cutting) often has a greater influence on evenness than richness. However, these patterns are not significant at the species level. This could be because dominant families in cut areas are represented by several species that are individually only moderately abundant; for example we recorded many Acanthaceae species, and often several in one quadrant.

At the species level of analysis, distance along the floodplain towards the pond was a significant predictor of both species richness and species diversity. This suggests that some unmeasured covariate of distance, such as pH, has a more important effect on species diversity and richness, than cutting. Further measurements of abiotic factors would therefore be useful in establishing the cause of this 'distance' effect. Those quadrants containing higher vegetation height, with larger plants, were also less palatable (for example *Clidemia hirta* is very woody, and many Cyperaceae members are unattractive to herbivores). We cannot be sure that some areas were initially not cut because they contained unpalatable species, rather than succession to unpalatability after non-cutting, but there is no reason to suspect the former scenario, especially when vegetation of intermediate height (not recently cut) was observed to contain many small unpalatable plants. Uncut vegetation close to trees was not sampled for this reason, as the proximity of trees might dissuade cutting.

Similarity testing revealed a low mean similarity between cut and uncut quadrants. This suggests that even if diversity and richness indices are similar between cut and uncut quadrants, the actual species recorded may differ considerably between the two microhabitats. Different vegetation types might have functional differences, for example, in nutrient demand, which could have important effects on both the physical environment and other components of the ecosystem (for example, cut areas with more palatable species) might support more insect herbivores. Low similarity also has important implications for the management of the floodplain to maximise biodiversity. The heterogeneous habitat created by patchy cutting may support more species (through creation of more niches), than an undisturbed habitat (Huston 1994). Comparison of this floodplain with one not used for human activities, and better investigation of abiotic factors on vegetation diversity, might help highlight these cutting effects.

Floodplain cutting is currently illegal and threatened by large fines, as it lies within 50 metres of the protected forest. Perhaps these penalties should not be too stringently enforced, though, for whilst high levels of cutting could cause a decline in floodplain diversity, decreased cutting could also have this effect. Cutting of the floodplain can also ease human impacts on the forest system, which is usually the main focus of conservation efforts.

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