Tropentag 2008
University of Hohenheim, October 7-9, 2008
Conference on International Research on Food Security, Natural Resource Management and Rural Development

Plant Diversity along Altitudinal Gradients in the Eastern Escarpment of the Rift Valley of Northern Ethiopia: Key for Conservation Priorities

Ermias Aynekulu

Center for Development Research (ZEF), University of Bonn, Walter-Flex-Str. 3, 53113, Bonn, Germany. Email ermias8@yahoo.com

Abstract

The forests of the mountainous landscapes of the northern Ethiopian highlands, which once were characterized by high plant diversity, have been degraded and fragmented for decades. Although forest and biodiversity conservations are major development priorities in northern Ethiopia, it has been difficult to implement conservation strategies at regional level due to reasons like land-use conflicts. The aim of this study thus was to identify the priority areas for biodiversity conservation. We measured data on the floristic and structural composition of vascular plants using twenty nine plots (2500m^2) with 100m altitudinal intervals, using two transects taken along the eastern escarpment the Rift Valley of northern Ethiopia ranging from 1000 to 2740m above sea level. In both sites, we found that the species richness of vascular plants increases steadily with increasing altitude up to 2000m and declines after that. The minimum species richness is 2 species per plot at the lower altitude whilst the maximum is 45 species per plot obtained between 1900 and 2100m. Hence, the altitudinal zone between 1900 and 2100m can be considered as a priority zone for biodiversity conservation. Such species-rich zones may serve as a habitat and corridor for birds and wild life and is an important seed source for vegetation restoration activities which are widely undertaken on the degraded sites of northern Ethiopia.

Keywords: Dessea forest, species richness, altitudinal zone, corridor, land use, northern Ethiopia

1 Introduction

Studying plant species distribution in response to environmental factors helps to generate information for a better understanding of ecological processes and in managing ecosystems. Altitude is a major environmental variable that controls the distributions of plant communities

in mountainous places like the northern Ethiopia. Plant species distribution in relation to altitude varies among ecosystems and plant life forms.

The extent of deforestation and habitat fragmentation caused by the over-utilization of forest resources to satisfy the food and energy requirements of the increasing population in the northern Ethiopian highlands is high (Machado *et al*., 1998; TFAP, 1996). Forest fragmentation influences the distribution of species (Rudel and Roper, 1997; Yirdaw, 2001) that may lead to the local extinction of endangered tree species (Aerts, 2006). The study area provides diverse habitats for plants in which the wet highlands of Tigray supports species like *Erica arborea* and within a distance of 5km we found the Acacia woodlands of the Afar lowlands. The response of plants distribution along the altitudinal gradients are less studied in northern Ethiopia and information which is necessary for effective conservation of biodiversity is meager (Aerts, 2006). The aim of this study was to examine the response of vascular plants diversity to altitude and identify the species-rich zones for conservation priority.

2 Material and methods

The study site

We collected data on the floristic and structural composition of vascular plants using twenty nine plots (2500m^2) with 100m altitudinal intervals, using two transects taken along the eastern escarpment of northern Ethiopia (Fig.1). The first transect runs from Esot village at the upper altitude (2740m a.s.l.) in Tigray to Koneba town of the Afar region at its lower end (1400 m a.s.l.) and the second one from Agoro village (Tigray highland, 2300 m a.s.l.) to Shaigubi village (Afar low land, 1000 m a.s.l.).

Large part of the study site is formed on shale, limestone, and sandstone of the Tertiary and Mesozoic era (TFAP, 1996). The diverse geological formations lead to soil variability and the dominating soil types in the study region are Leptosols, Cambisols, Vertisols, Regosols and Arenosols.

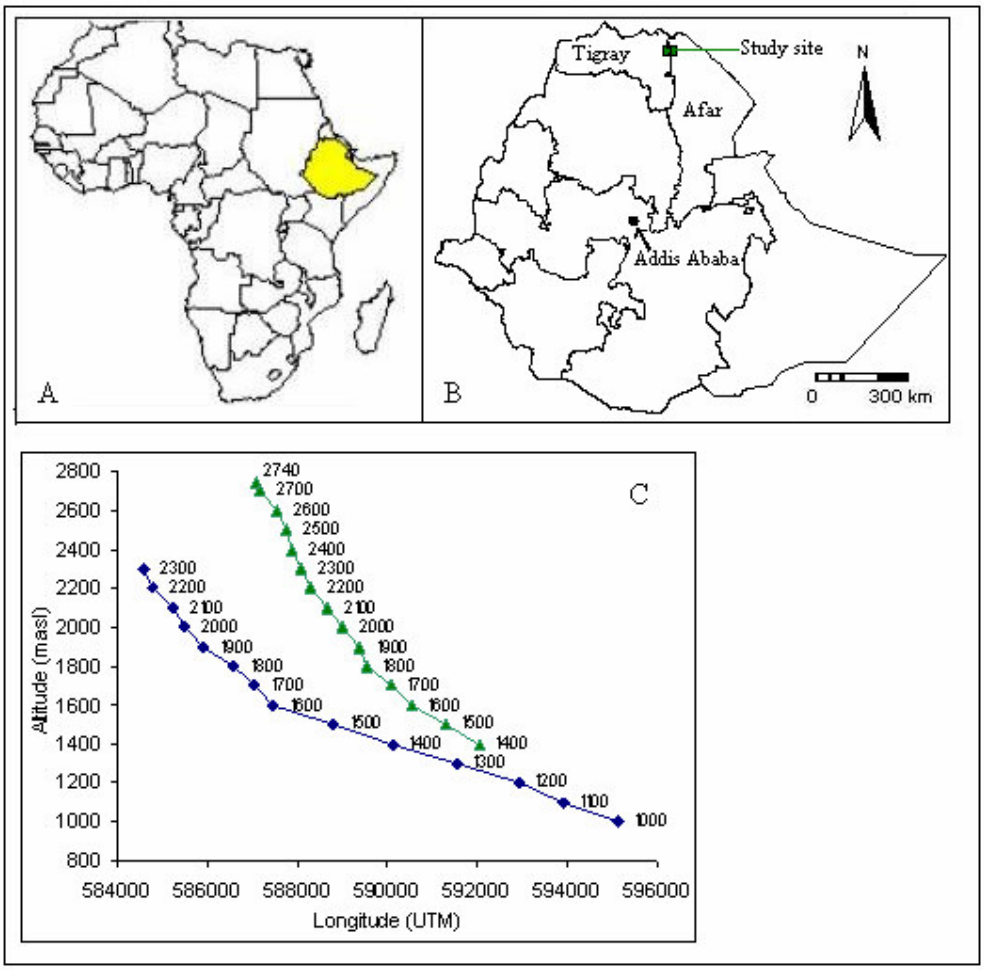

Figure 1. Location of the study sites indicating Ethiopia on the map of Africa (A), the study sites on the map of Ethiopia (B) and the distribution of plots at Agoro (■) and Esot (▲) sites (C). The x-axis indicates the longitude in UTM: (Projection: U.T.M. Zone 37 (north), Datum: Adindan).

Methods

Species distribution along altitudinal gradients was examined using transects drawn across the Tigray highlands towards the Afar lowlands using topographic maps (1:50,000) (EMA, 1994). We measured height and diameter of plants breast height (DBH) for plants taller than 1.5m, herbs and smaller shrubs were identified and counted. Plant specimens were collected and identified in the National Herbarium of Addis Ababa University. We determined total species richness, species richness of herbs, shrubs and tree growth forms and the Shannon-Wiener diversity index to measure diversity (Krebs, 1989). The Shannon-Wiener diversity index includes species richness and evenness which indicates the relative abundance of each species and was calculated as given by Magurran (1998).

3 Results

Total species richness was lower at the higher and lower altitude while reached the maximum around 2000 m a.s.l. The minimum species richness we found is 2 species per plot at 1000m a.s.l., whilst the maximum is 45 species per plot obtained between 1900 and 2100m a.s.l. The relationships between vascular plants diversity and altitude were significant and explained by second degree polynomial regressions (Fig. 2).

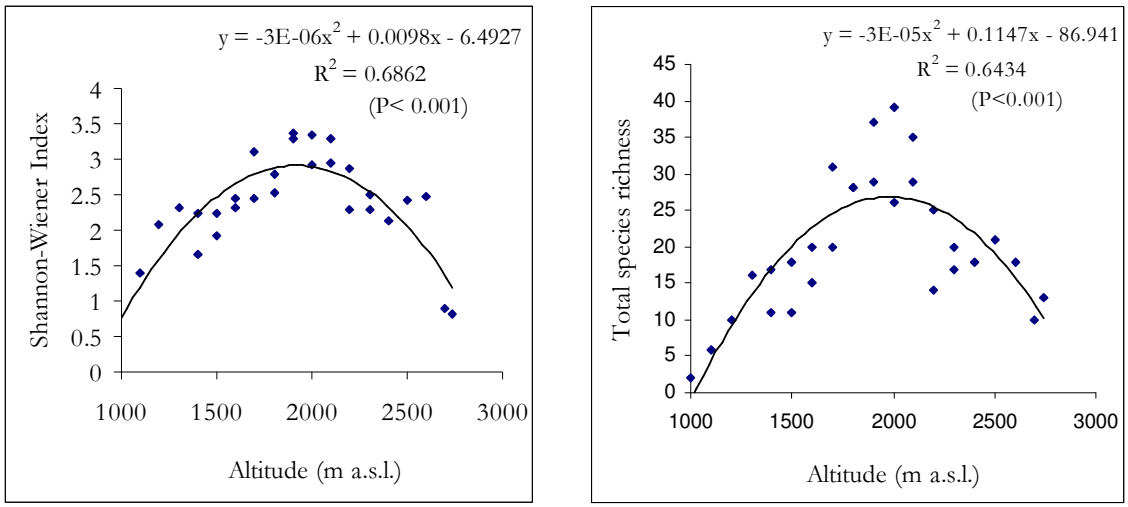

Figure 2. Vascular plants diversity per plot along altitudinal gradients in the eastern escarpment of the Rift Valley, northern Ethiopia: Species richness (left) and Shannon-Wiener Index, α diversity (right).

Species richness and altitude were highly related for all life forms; herbs (r^2=, 0.55 $p<0.001$), shrubs (r^2=0.28, p=0.012) and trees (r^2=0.38, p=0.002). The response of herb species richness to altitude is more similar to the total species richness than the shrub and tree species. Hence, the distribution of vascular plants along the north-eastern escarpments of the Rift Valley of the northern Ethiopia is highly influenced by the herb species richness (Fig. 3).

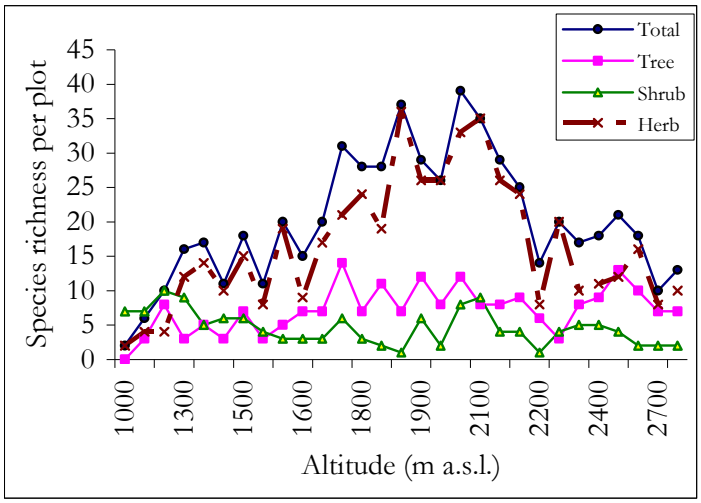

Figure 3. Herb, shrub, tree and total species richness pattern along altitudinal gradients in the eastern escarpment of the Rift Valley, northern Ethiopia.

4 Discussion

As indicated in Fig. 2, we found that total vascular plants diversity has a hump-shaped distribution along altitudinal gradients which is well explained by second degree polynomial regression equations. Total species richness increases with altitude, reached its peak in the shoulder of the landscape (ca. 2000 m) and declines then after. We found the altitudinal range 1900-2100m as the species rich zone which is closely similar to the result found in Guandi Mountain, China (Gao. and Yun-xiang, 2006). One reason for the high diversity of vascular plants around the mid-altitude might be its optimum climatic conditions that allow many species to coexist (Hemp, 2006). It may also be the fact that the mid altitude is far from human population settlements. The low values of the Shannon-Wiener Index at the higher altitudes were due to the dominance of *J. procera* which is a dominant native tree species in the highlands of northern Ethiopia.

Human influence on the forest through deforestation, livestock, and agricultural land expansion also has impact on structure and floristic composition of the local plant communities (Chawla *et al*., 2008; Taddese, 2001). Dessea forest which is dominated by *J. procera* and Olea species seems in a state of retrogressive succession in which large parts of it has been replaced by invasive shrubs and herbs like *Cadia purpurea* and *Tarconanthus camphorates.* Many big trees have been removed from the forest since the occupation of the Italian colony and the high number of stumps we observed in the study sites is evidence for that. There was a high mortality of trees in the escarpment especially at the Esot side of the forest where thousands of *Junipers* and *Olea*

trees were dead while standing. This might create canopy that favors the invasions of fast growing pioneer species. The higher contribution the herb species for the total plant species in the study site (Fig.3) is more likely due to the degradation of the natural forest.

5 Conclusions

In developing region like northern Ethiopia where land-use conflict are common between the forestry and the agricultural sector, it is hardly possible to conserve large areas (Margules *et al*., 2002). Therefore, it is important to prioritize species-rich zones for biodiversity conservation. Many of the forest patches are found on sloppy terrains which are less suitable for agriculture activities. This may be a good opportunity to get more land to implement biodiversity conservation goals. Since, the natural forest remnants of northern Ethiopia are in a rapid state of change, it is important to give more conservation priorities and take urgent action to protect these habitats.

References

Aerts, R. 2006. Dispersal and recruitment of *Olea europaea* ssp *cuspidata* in degraded Afromontae savanna: implications for forest restoration in the highlands of northern Ethiopia. PhD Thesis, Katholieke Universiteit Leuven, Belgium.

Chawla, A., S. Rajkumar, K.N. Singh, B. Lal, R.D. Singh, and A.K. Thukral. 2008. Plant species diversity along an altitudinal gradient of Bhabha Valley in western Himalaya. Journal of Mountain Science 5:157-177.

EMA. 1994. Topographic map. Ethiopian Mapping Authority, Addis Ababa, Ethiopia.

Gao., J.-f., and Z. Yun-xiang. 2006. Distributional patterns of species diversity of main plant communities along altitudinal gradient in secondary forest region, Guandi Mountain, China. Journal of Forestry Research 17:111-115.

Hemp, A. 2006. Continuum or zonation? Altitudinal gradients in the forest vegetation of Mt. Kilimanjaro. Plant Ecology 184:27 –42.

Krebs, C.J. 1989. Ecological Methodology. Harper Collins Publishers, University of British Colombia, New York.

Machado, J.M., A. Pe´rez-Gonza´lez, and G. Benito. 1998. Paleoenvironmental Changes during the Last 4000 yr in the Tigray, Northern Ethiopia. Quaternary Research 49:312-321.

Margules, C.R., P.R..L., and P.H. Williams. 2002. Representing biodiversity: data and procedures for identifying priority areas for conservation. J. Biosci. 27(Suppl. 2):309-326.

Rudel, T., and J. Roper. 1997. Forest Fragmentation in the Humid Tropics: A Cross–National Analysis Singapore Journal of Tropical Geography 18 99.

Taddese, G. 2001. Land Degradation: A Challenge to Ethiopia. Environmental Management 27:815-824.

TFAP. 1996. Tigray Forestry Action Plan (TFAP). Mekelle, Ethiopia.

Yirdaw, E. 2001. Diversity of naturally-regenerated native woody species in forest plantations in the Ethiopian highlands. New Forests 22:159-177.