A multi-disciplinary study of treeline dynamics in the North Ethiopian highlands

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Important ecosystem services of high altitude forests in tropical Africa are under increasing environmental and human pressure. The afro-alpine treeline forms an apparent and temperature-responsive vegetation boundary and is therefore potentially valuable as a proxy of climate change in the tropics. However, a review of the current literature about treeline dynamics in tropical Africa (fig. 1) indicates that the potential effect of climate change on the treeline is obstructed due to high human pressure and growing human population densities (fig. 2,3). On average the treeline is depressed below its climatic limit by 400 ± 300 meter, but regional differences are high and there are still many uncertainties.

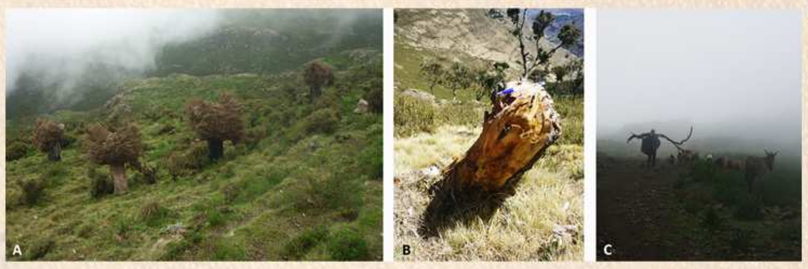

Fig. 2: Anthropogenic pressure on the high altitude forest. (a) Gathering of small branches as firewood (b) *Erica* trunk (c) transport of *Erica* tree

Fig. 3: Livestock browsing impedes regeneration of *Erica*. (a) Sheep brwosing (b) Uprooting of Erica stumps destroys regeneration from the tree roots (inset).

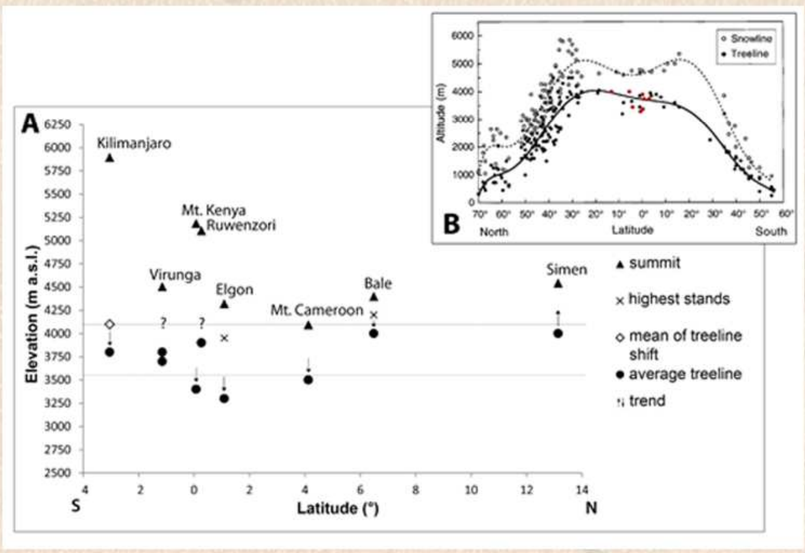

Fig. 1: Synthesis of tree line dynamics in the tropical African highlands: (a) tree line dynamics in the African tropical highlands, arrows indicate the treeline trend. The zone between the dashed lines refers to the upper tree line limit zone described by Hedberg (1951); (b) Korner (1998) adjusted with tree line elevations from the tropical African highlands in red.

A MULTI-DISCIPLINARY APPROACH

The Erica arborea L. treeline is studied over a century in in the north Ethiopian highlands (fig. 4), using satellite imagery, aerial photographs, repeat photography and dendroclimatology.

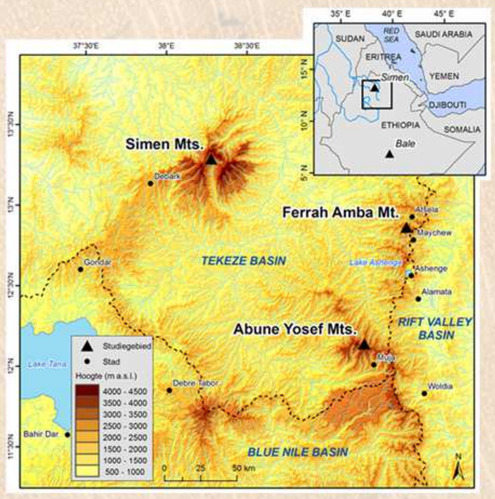

Fig 4: Location of the three study areas. Simen Mts. (4620 m), Ferrah Amba Mt. (3939 m) and Abune Yosef Mts. (4260 m).

Repeat photography is proven a unique tool for the identification of treeline dynamics on the long-term (fig. 5, 6). Results in the Simen Mts. indicate a treeline rise of more than 100 meters since the early 20th century.

Fig. 5: Repeat photograph of Jinbar valley in the Simen Mountains indicating a treeline shift of 70 meter upwards and forest cover change over a period of 48 years. 1966 photograph by Nievergelt © .

In contrast, historical **satellite and aerial imagery** indicate that there has been strong deforestation since the last 30 years and a significant ($p < 0.05$) but small rise of the treeline elevation of 11 ± 4 vertical meters in Lib Amba Mt.

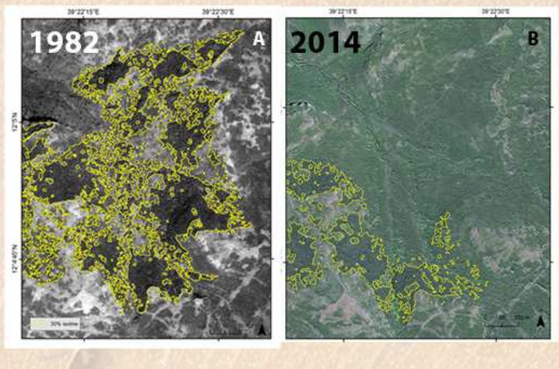

Fig. 6: Forest detection (a) aerial photograph of 1982 (EMA) (b) Google Maps satellite imagery 2010 (Google)

Dendroclimatological results indicate a correlation between tree ring width and interannual precipitation patterns. But, since treelines in the African tropical mountains are strongly disturbed by human and livestock pressure, they cannot simply be used as a proxy for climate change.

Fig. 7: Tree ring width counting of stem disc

Fig. 8: Examples of repeat photographs in the Simen Mountains. (a,b) Kedadit (c,d) Muchila Afaf and (e,f) Saha. The historical photographs are copyrighted by Larry Workman © and Hans Hurni © .

References:

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